MC0353

Encode 1

NHS Estates
An Executive Agency of the Department of Health

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About this publication

Encode is a key guidance document which describes how to improve energy efficiency in existing health care establishments by means of a comprehensive strategy to facilitate progress from piecemeal to total energy management; it complements the information available from the Energy Efficiency Office. While not mandatory, it will assist greatly in planning an energy-saving campaign.

Encode is published as a set of three documents; this volume, **Encode 1**, contains information on the Energy Survey and Audit Method (ESAM), energy monitoring, identifying potential energy-saving measures and energy management planning.

Encode 2 (to be published later in the year) will provide detailed practical information and technical advice in support of the principles and procedures in Encode 1. Subjects covered will include good housekeeping, standards, mechanical and electrical services, finance, training, and guidance on refrigerants.

A third document, 'A strategic guide to energy management', was published for General Managers and Chief Executives with the aim of stimulating a management commitment to the principles of energy efficiency and conservation.

The contents of the publication are endorsed by the NHS Management Executive for the NHS in England, the Welsh Office for the NHS in Wales, the Health and Personal Social Services Management Executive in Northern Ireland and the National Health Service in Scotland Management Executive.

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Encode 1

In the preface of the 1985 edition of Encode the importance of releasing resources for improved patient care by promoting energy efficiency was stressed. More recently, attention has been focused on the broader environmental issues of energy conservation and the contribution that can be made to stabilising CO_2 emissions as well as reducing the output of the other energy-related pollutants, thus helping to protect our global heritage. To that end, a 15% energy-saving target in the five-year period up until 1995/96 has been set as part of the broader Government-wide initiative.

Such savings should be well within the capabilities of health authorities and NHS Trusts as recognised by the Audit Commission in their 1991 papers (''Saving energy in the NHS'' for England and Wales and the Scottish Office Audit Unit Report 1991).

Efforts to save energy will continue to release resources for improved patient care and will make a significant contribution to the objective of stabilising CO_2 emissions.

The guidance in this new edition of Encode is based on the experience gained in the use of its predecessor and a survey has been helpful in determining the new layout and content of this edition. The further development of associated computer software will also simplify its use and implementation of the guidance.

It is recognised that the major users of Encode 1 will be estates managers and facility managers, but the importance of the support of general managers and chief executives has not been overlooked. The publication of the 'Strategic guide to energy management' for general managers and chief executives had that aim in mind.

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1.0 Introduction

Encode – what is it?

1.1 Encode describes how to improve energy efficiency in existing health care establishments by means of a comprehensive strategy to facilitate progress from piecemeal to total energy management. The guidance complements the information available from the Energy Efficiency Office.

1.2 Encode emphasises the importance of:

- accurate monitoring of energy consumption;
- an energy audit of buildings and plant;
- setting targets for reduced energy consumption;
- identifying and assessing the economic and strategic viability of potential energy-saving measures;
- carrying out effective option appraisals;
- ranking the proposed measures to provide a basis for sound energy management planning.

1.3 The opportunity to incorporate the lessons learned from the Low Energy Studies should not be overlooked, particularly during estate rationalisation.

1.4 Encode is published as a set of three documents available from HMSO bookshops and accredited agents:

(i) 'Encode 1' contains information on the Energy Survey and Audit Method (ESAM), energy monitoring, identifying potential energy-saving measures and energy management planning;

(ii) 'Encode 2' provides detailed practical information and technical advice in support of the principles and procedures in 'Encode 1'. Subjects covered include good housekeeping, standards, mechanical and electrical services, finance and training;

(iii) 'Executive guide: "A strategic guide to energy management"' promotes the need for an energy strategy to general managers and chief executives with the aim of stimulating management commitment to the importance and principles of energy efficiency.

1.5 These documents are supported by a number of computer programs, which are described briefly in Section 6, and in more detail in the 'Software support manuals' supplied with the programs. These and other relevant support material are listed at the end of each section.

1.6 The accompanying flowchart (Figure 1) provides a visual summary of the principal activities embodied in Encode.

Encode – its purpose

1.7 The effective and efficient use of fossil fuels, electricity and water at the operational level has traditionally followed a strategy of employing well tried and tested measures, for example:

- good housekeeping;
- investment in building insulation;
- improved heating controls;
- heat recovery.

The application, relevance and economics of such measures are generally well documented and back-up/empirical data is often adaptable to other situations. However, as energy management becomes more commonplace, fewer simple, off-the-shelf solutions are left to apply, that is, the most obvious areas have been dealt with. It thus becomes necessary to search for new ideas and applications.

1.8 A key feature of Encode is ESAM – the Energy Survey and Audit Method. For each managed site, this method aims to:

a. identify where each unit of energy is used;

b. attribute consumption and cost to particular buildings and/or their services;

c. question and justify the cost of such services against the standards required and the benefits derived;

d. draw comparisons and identify measures that would reduce consumption and hence cost.

Particular benefit is derived from the quite deliberate process of focusing the attention of the energy auditor on individual components which might otherwise be easily overlooked within a complex site.

1.9 The ease and accuracy of completing a meaningful survey and audit will be dependent on a number of factors including:

- the quality and extent of retrospective and current records;
- the extent and relevance of metered services;
- the homogeneous nature of the building and engineering services;
- the size and complexity of the site.

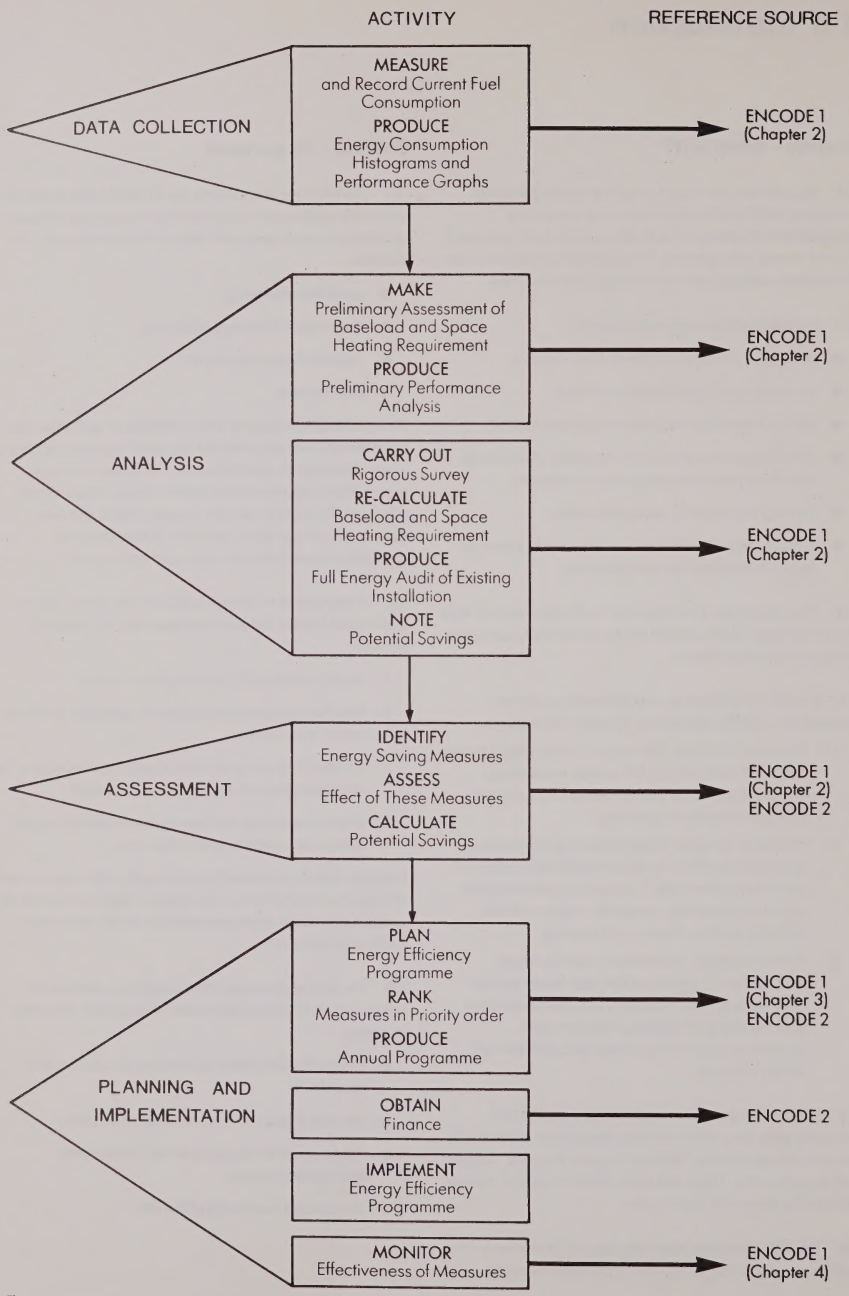

Figure 1 Encode in use

1.10 Many hospitals have evolved over a long period of time during which different economic conditions will have resulted in a variety of building and engineering design standards. Consequently there may be many impediments that will inhibit a cheap and precise audit in the first instance.

1.11 Even if the initial audit is limited, it is likely to highlight shortcomings in energy management (the absence or inadequacy of meters, for example) and encourage the implementation of better systems. When improvements have been made, a more thorough audit may then be undertaken.

1.12 ESAM not only provides important short-term benefits, but also has a long-term value. The audit process, and the examination of all the measures available to reduce expenditure, quantify savings potential; this can have strategic value for estate rationalisation purposes. Further, once the decision has been made to retain estate assets, the ESAM data becomes the base from which future energy management systems may be developed and effectiveness measured.

1.13 Accurate information is critical to ESAM. It is an inescapable fact that many NHS establishments have inadequate sensing and metering devices. The energy manager's catchphrase, "to measure is to know", is therefore fundamental; it underlines the value of building management systems encompassing a high level of monitoring.

Energy efficiency

1.14 At its most simple, the aim of energy efficiency is:

> to minimise the consumption and expenditure of fossil fuels, electricity and water within rational limits without reducing standards.

1.15 This, however, is a broad generalisation containing wide-ranging aims, opportunities and implications. Energy efficiency necessitates:

a. identification of all the measures available to reduce consumption and attendant costs;

b. establishing the means to implement those measures;

c. return on investment evaluations;

d. utilisation of the cheapest energy products consistent with quality;

e. purchasing at the best market rates and tariff conditions;

f. accounting for any increased revenue charges elsewhere;

g. regular monitoring of consumption and the maintenance of records;

h. sustained support from all staff;

j. maintenance of comfort and safety standards;

k. planned and organised change, in harmony with other associated estate and service development;

m. adaptation to changing circumstances;

n. the incorporation of energy conscious design into new developments;

p. keeping abreast of technological developments in the building and healthcare sector which have energy efficiency potential;

q. knowing at any point in time the total savings potential for each managed site and its constituent units;

r. a flexible approach to avoid being locked into one source of energy supply.

1.16 In essence, the overriding aim is a reduction in expenditure by:

a. selecting cheaper tariffs;

b. reducing consumption;

c. changing the balance of energy sources.

Target areas

1.17 It is important to emphasise that quite separate management actions are required in order to meet energy efficiency targets in different areas. The fact that there may be considerable overlap and interaction between these areas is unimportant compared with the requirement to recognise and stipulate these separate initiatives.

1.18 Good housekeeping may be practised by both accommodation users and providers.

Users of accommodation and services

1.19 Department heads and their staff may be encouraged to promote conservation in several ways, for example:

- turning off lighting and heating when not required;
- keeping doors and windows closed when heating is switched on;
- avoiding hot and cold water wastage;
- reporting malfunctions and poor controls;
- making suggestions for energy saving.

1.20 It is important to appreciate that some of the resultant savings from these "client" housekeeping measures will not be permanent unless enthusiasm and discipline are maintained.

1.21 Feedback is also important here; for example, production of a quarterly bulletin on energy matters highlighting achievements made will often sustain the impetus of good housekeeping.

Providers of accommodation and services

1.22 Good housekeeping measures by estate management are equally as important. They should:

a. collect, collate, maintain and analyse records and data;

b. monitor performance, set targets and measure effectiveness against those targets;

c. respond to client suggestions and complaints;

d. co-ordinate feedback and targets with client or energy management groups;

e. complete and refine the energy audit process;

f. incorporate conservation within maintenance and operational activity – plant efficiency, control effectiveness, etc;

g. apply energy conscious design in all changes and developments;

h. control all potential uses of energy. This means consultation on the energy needs of equipment and individual departments.

Low-cost improvements

1.23 There should be scope within a normal revenue budget to encourage a wide range of minor, low-cost improvements. These should cause no disruption to normal services and could well be incorporated into routine maintenance activity. Many proposals will originate from ideas provoked by good housekeeping practice, and follow-up is important to demonstrate that management is responsive to staff suggestions.

Capital investment

1.24 Proposals which demand higher levels of investment will be subject to detailed scrutiny in feasibility and economic terms, in relation to cash flow and in terms of the implications they will have upon other estate development proposals, both short- and long-term.

1.25 The distinction between capital investment and low-cost improvements may not reflect the current capital ceiling level. There may also be alternative, intermediate levels of provision. Whatever the source of finance, however, it is imperative that the staff who initiate and promote energy saving know where to direct their proposals.

Energy management philosophy

Appointing an energy manager

1.26 The nomination of an individual responsible for energy efficiency is essential.

1.27 The resources devoted to energy management should reflect the size, age and condition of the site(s) and overall energy expenditure. Resources should be allocated in a manner which ensures the maximum effective return, and which reflects past and potential energy savings. The responsibility for energy efficiency need not be confined to a single site but can be incorporated within the role of unit or district estate management, so long as the commitment is enforced, reviewed regularly and maintained.

1.28 Within each site, however, responsibility for savings should not be left entirely to an energy manager. From their intimate operational working knowledge of what is happening within the estate day by day, other estates staff and the users of accommodation can make valuable contributions. The creation of local energy management groups is an excellent way of harnessing the influence and knowledge of such personnel.

1.29 Similarly, an energy manager must have access to, and interact with, the decision makers in general management. Changes to operational policy and practice, access to funds, interaction with project planning and the design process, plus input into strategic and operational planning, all need to be seen as attainable. It may well be that energy considerations could make a significant contribution to estate rationalisation plans, especially where poor performance cannot be improved over the short term.

1.30 An energy manager can have a dramatic effect on the use of fossil fuels, and this should be a prime responsibility of the post. The use of electricity is, however, in the hands of practically every user of a building and is thus harder to control; one of the main duties of an energy manager, therefore, is to encourage the judicious use of this fuel.

Energy consultants

1.31 Energy consultants normally limit their services to professional advice within a status report based upon site surveys plus scrutiny of past and current records taken at one point in time. Energy management, however, is an on-going process for which the consultant's advice and report is no substitute. Nevertheless, consultants can be part of a managed service used to generate fresh perspectives, investigate specific areas of concern, or more simply to provide a survey and audit base from which energy management strategies can be developed.

Resources required

1.32 The management resources required will depend upon the scale and complexity of improvement potential, and the desired speed of change. Part of the resource might be employed on non-recurring outlays such as consultants, fixed-term contracts, or by simply diverting management resources from elsewhere within estate management for a finite period.

1.33 As with individual measures, energy management must be cost-effective. A guide to the costs will be established by assessing the savings sustainable in each year and discounting these by Discounted Cash Flow (DCF) methods.

1.34 A national norm of between 1% and 2% per annum of total energy expenditure would be justifiable, while a minimum of 1% per annum is necessary as a routine management commitment. This allocation should provide the resources to:

a. maintain the necessary records to measure the effectiveness of change;

b. establish a focal point to collate and disseminate management and technological information;

c. leave spare capacity to investigate and advance the changes necessary to meet energy management targets.

Trends in energy expenditure

1.35 A target reduction of 1.5% per year in energy consumption was set during the 1980s, in line with the central Government's earlier energy efficiency campaign and monitored by the Public Accounts Committee (PAC). This has been superseded by the Government's new 15% energy-saving initiative over the five years 1991/92 to 1995/96.

1.36 The most recent figures for England indicate that the total energy costs, including laundries, exceed £250 million. Of this amount, hospital electricity costs were over £103 million and fossil fuel, used mainly for heating and hot water, over £115 million. This represents a net increase, not allowing for inflation, of £10 million over the expenditure in 1989/90.

1.37 Increasing electricity consumption is a cause for concern, in both cost and environmental terms.

1.38 To focus attention on this problem, new primary energy performance indicators (PEPIs) were introduced in 1992.

1.39 Figure 2 below is derived from hospital returns for England and shows the trends of energy consumption from 1972/73, the first oil crisis, and highlights the increase in the use of electricity.

Support material

1.40 Videos: Entrain;
Building energy efficient hospitals

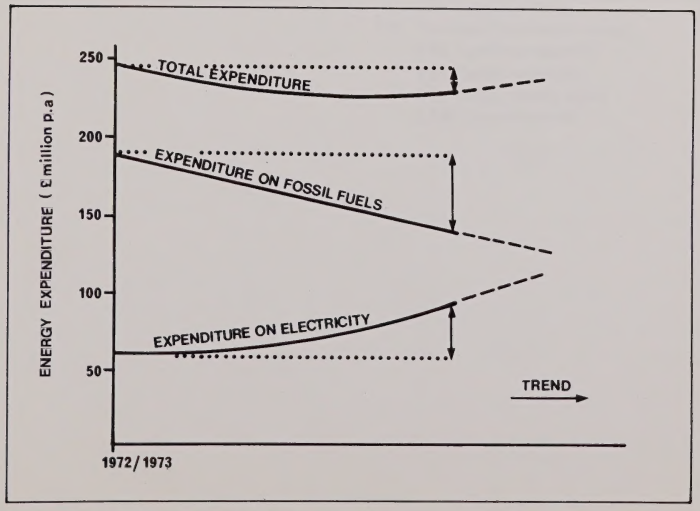

Figure 2 Trends in energy consumption in health care premises

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2.0 Energy Survey and Audit Method

Overview

2.1 The Energy Survey and Audit Method (ESAM) is designed to assist energy managers to identify inefficient use of the energy provided by the boilerhouse. ESAM has been in use in the NHS for several years and has proved invaluable.

2.2 Assessed energy requirements of a site (in the form of generated steam or hot water) are compared with actual consumption, allowing potential savings to be deduced.

2.3 Electricity consumption for lighting, plant, equipment, space heating, etc needs to be assessed separately (a method is suggested in Chapter 9). The use of gas for catering, direct heating, etc is not covered by ESAM and should be assessed by whatever means is preferred but using the ESAM philosophy.

2.4 Electricity and gas assessments may be added to those of the boilerhouse in the final audit to provide a complete energy profile.

2.5 ESAM should be regarded as a flexible tool which may be applied to any particular site, rather than a rigid method of analysis. The ESAM procedure accounts for the energy which is produced by central or satellite boilerhouses for:

- the baseload for domestic hot water, steam and hot water use for ancillary equipment (for example in laboratories, kitchens, laundries, etc), distribution and circulation losses. These produce a more or less constant demand throughout the year;
- the space heating load which is almost totally dependent on the climatic temperature and needs to be degree day adjusted.

2.6 These two loads need to be separately assessed; the aggregate figure can then be compared with actual consumption. Any difference gives an initial indication of the potential savings available.

2.7 This section describes what might be called a manual method of assessment as it relies on the completion of uniquely designed forms. However, a number of computer programs are also available which aim to relieve the burden of form filling, and to provide greater flexibility for change and modelling of energy-saving measures. The five programs, which can be run in conjunction with the manual method, are:

a. Enbuild;

b. Enplant;

c. Enaudit;

d. Encomp;

e. Encost.

2.8 Before commencing the audit process it is advisable to study the facilities offered by these programs: see Chapter 6.

2.9 The ESAM procedure is divided into three parts:

a. site energy performance analysis;

b. assessment of site energy requirement;

c. assessment of potential savings.

Site energy performance analysis

2.10 This stage involves compilation of a site's energy consumption profile over previous years, against which current consumption can be meaningfully compared. The data may be collated from boilerhouse fuel records, invoices or bills. The computer programs Enmats (Energy Monitoring and Targeting System) and Encap may also be used to assist this analysis.

2.11 The ESAM procedure differentiates between the energy required for temperature-dependent space heating, and that for the more or less constant baseload. A preliminary assessment of the space heating and baseloads is carried out, which can be compared with the actual consumption to indicate potential savings. This assessment can then be refined in the 'Assessment of site energy requirement'.

Assessment of site energy requirement

2.12 This requires a more accurate overall assessment of the energy needed for space heating and the baseload.

2.13 To assess the space heating requirement, an energy audit is carried out which details fabric and infiltration losses. It relates these losses to an occupancy factor and to degree day data to give the theoretical energy consumption in GigaJoules (GJ) per annum.

2.14 The baseload assessment is fundamentally the same as in the site energy performance analysis, but uses more accurate data and, where necessary, more detailed assessments of baseloads.

Assessment of potential savings

2.15 Knowing the actual energy consumption (ascertained in the site energy performance analysis) and the more accurate theoretical consumption (assessment of site energy requirement), it is reasonable to assume that the difference

between these two figures represents potential savings that could be achieved by better management and the reduction of excessive heat losses.

2.16 It is important to appreciate that the procedure relies on an accurate site survey and assessment of heat and energy losses. Nonetheless, estimates of potential savings will probably contain a degree of error due to inaccurate assessments or use of unreliable norms. Metering or measurement should therefore always be used to obviate the use of norms.

2.17 A set of standard stationery is included in the Appendix. These forms allow a full, formal written record to be produced of the whole procedure and can also serve as a permanent record ready for possible changes in the future.

2.18 In addition, a fully referenced worked example is included in Chapter 8, which follows the ESAM procedure step by step, while the specific data relating to this worked example is presented on the standard forms which are also included in the Appendix.

Site energy performance analysis

2.19 The object of this section is to review boiler fuel energy consumption data, identify its distribution and present it in graphical form. This gives an energy manager a visual means of comparing current and previous fuel consumption on a month-by-month basis and allows for a preliminary assessment of performance. The ESAM method requires consumption records for a complete year in order to provide base data for analysis and subsequent comparisons.

2.20 The accompanying flowchart (Figure 3) shows that the process may be broken down into the following steps.

Step 1: Site details

2.21 The details of the site and all boilerhouses should be recorded on Form 1. The exposure of a site (which affects the heat transfer rates used in the space heating calculations) should be classed as Sheltered, Normal or Severe.

2.22 For each boilerhouse, specify the "Degree Day" (DD) base, the annual degree days and the number of degree days in the heating season. Standard degree days (to a base of 15.5°C) should be used for boilerhouses which supply administrative or residential buildings only. Hospital degree days (to a base of 18.5°C) should be used for boilerhouses that supply "hospital" buildings (wards, theatres, etc) or buildings housing mixed accommodation.

2.23 The degree days recorded should be the 20-year average for the site and degree day temperature base selected. These can be obtained from a local weather station or from the degree day tables issued monthly by the Department of Health.

2.24 The 20-year figures are used in order to provide an assessment of average space heating requirements, against which consumption in any particular year may be compared. Two figures may be required: always the degree days for the full year, and where this differs, the degree days for the heating season only: those months when there is no heating whatsoever being omitted. Where heating is supplied for part of a month, the relevant proportion of the month's degree days should be used. The 'degree days' section of Chapter 7 covers degree days in greater detail and includes sample data sheets.

Step 2: Collation of fuel records

2.25 The next step is to identify monthly boiler fuel consumption. The data may be recorded on Form 2, using a separate form for each boilerhouse.

2.26 Where different fuels are used, these should be recorded separately, in their units of supply, then converted to GJ for aggregation. (Calorific values for common fuels are given in Chapter 7, Table 2 with some conversion factors in Table 4.)

2.27 It is essential that:

a. the consumption recorded is that for the boilerhouses only, not for the whole site;

b. the figures are the true monthly values. This is best achieved by using the boilerhouse meter readings taken at the end of each month, irrespective of any other accounting procedures;

c. calorific values should be gross or net throughout the calculations.

2.28 The degree days for each month should also be recorded on Form 2. Ideally, these should be taken from the data provided by a building management system or local weather station; again, the degree day tables issued monthly by the Department of Health may be used in the absence of local information. The figures used should be those for the degree day base specified for the boilerhouse on Form 1. Here the degree days for the year actually being analysed are used so that consumption is related to the weather conditions for that year.

Step 3: Consumption histogram

2.29 The drawing of a simple histogram (Figure 4) highlights the seasonal variation in energy consumption.

Step 4: Actual performance

2.30 Since much of the energy produced is used for space heating, consumption shown in Figure 4 varies with the external temperature. This can be compensated for by relating monthly energy consumption to degree days (Figure 5) to produce a straight line referred to as the

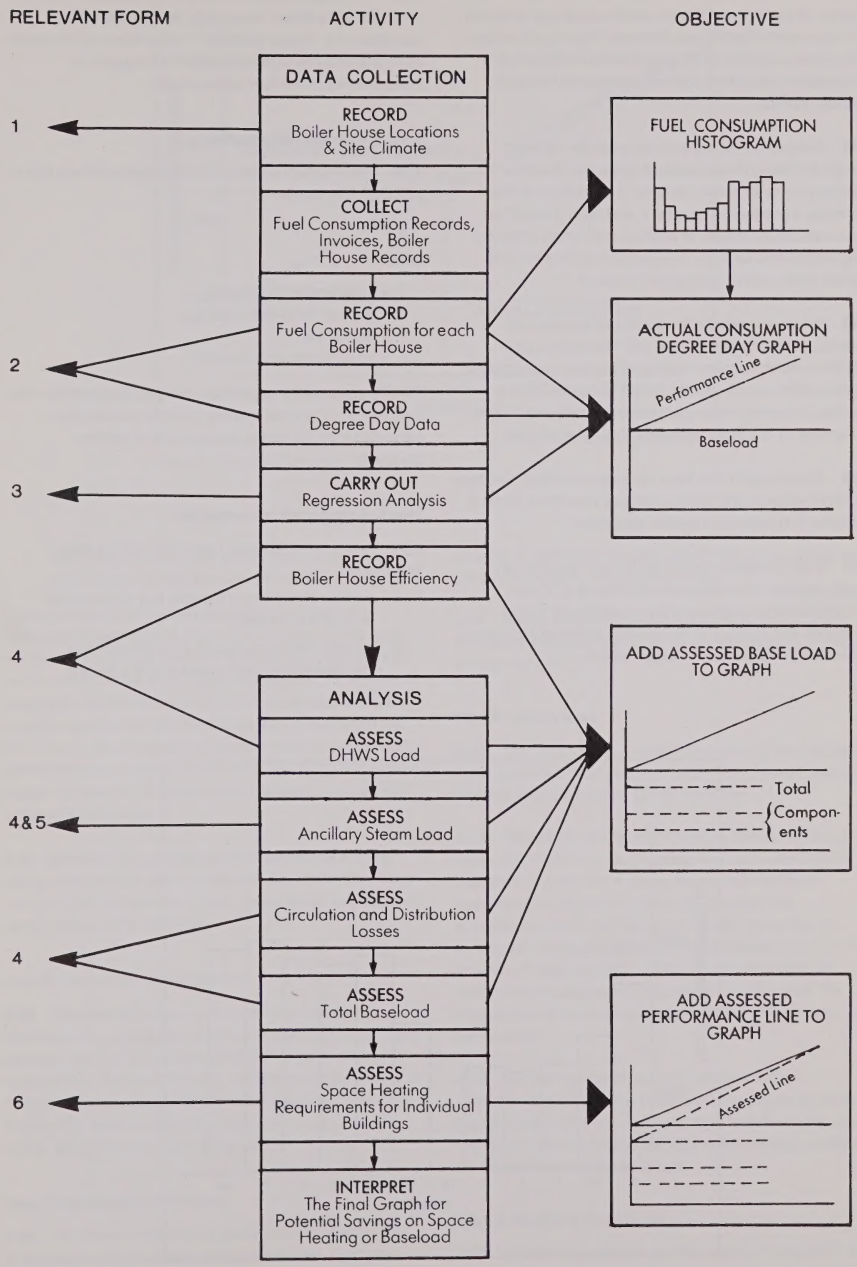


Figure 3 Site energy performance analysis

"Actual Performance Line". In practice, however, there will be a scatter of points about the line which will be due to factors other than space heating requirements. These could include poor control response, temporary shutdown of plant, or consumption data which does not correspond exactly to calendar months.

2.31 If the scatter is so great as to preclude a realistic straight line being drawn by visual inspection, it will be necessary to use regression analysis. A description of this technique is provided in Chapter 7, and Form 3 should be used to record the details. In addition the Enmats computer program includes facilities for regression analysis and it is applied in the worked example in Chapter 8.

2.32 Initially an energy manager should examine the boilerhouse records and exclude from the analysis any months in which no space heating whatsoever was supplied. (Consumption in such months is likely to be close to the baseload.) Months where space heating is provided for part of the time, or to limited areas only, should be included.

2.33 If consumption has been accurately recorded, the data should reveal a good fit, with a correlation coefficient of 0.9 or higher. (1.0 indicates a perfect correlation.)

2.34 If the correlation coefficient is lower than this, an energy manager should examine the degree of scatter and interpret the results using his knowledge of the site conditions and accuracy of the monthly readings; this analysis will enable the exclusion of "rogue" points.

2.35 The actual performance line will not pass through the origin but will intersect the energy axis at a point which represents the "Actual Baseload". This is drawn on the graph as a horizontal line to demonstrate the temperature independence of the non-heating load.

Step 5: Average consumption

2.36 The equation for the actual performance line is that of a straight line, that is:

$$y = mx + c$$

where

y = consumption (GJ/month);
m = slope of the graph (GJ/DD);
x = degree days;
c = actual baseload (GJ/month).

The average monthly degree days can be calculated from the data on Form 2 and the average monthly consumption calculated from the above equation and plotted on the graph.

Step 6: Anticipated consumption

2.37 Two graphs have now been produced for each boilerhouse:

(i) a simple histogram of monthly fuel consumption throughout the year;

(ii) monthly fuel consumption against hospital or standard degree days showing both a sloping

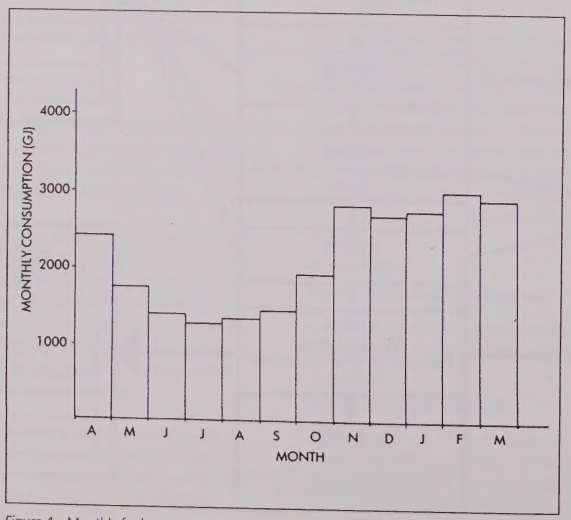


Figure 4 Monthly fuel consumption

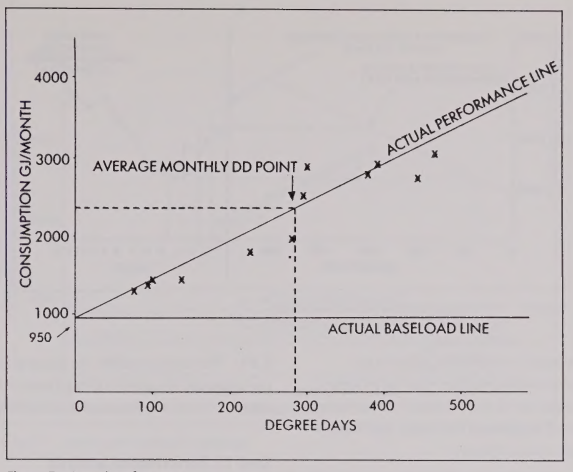


Figure 5 Actual performance

line known as the actual performance line, and a horizontal line known as the actual baseload.

These can now be combined to establish a profile of consumption with degree day variation (Figure 6). For each month, draw a vertical line from the number of degree days for the month to the actual space heating line of the previous (base) year. At the intersection, draw a horizontal line to the month in question to give the anticipated consumption for that month. The actual performance line may thus be used to predict fuel consumption in any particular month and provide a direct comparison of actual versus predicted consumption as the year progresses.

2.38 Reduced energy consumption targeted by energy-saving measures can also be shown by this technique, as can a comparison with previous years' consumption by preparing yearly graphs in the same way.

Introduction to the following steps

2.39 The assessed space heating performance and the baseload now need to be calculated in order to indicate likely potential savings. It is convenient at this stage to work backwards by first analysing the components that combine to form the total baseload. The computer program Enplant will assist in this analysis, which is carried out in steps 7 to 11 below, using Form 4 to record the data.

Step 7: Boilerhouse efficiency

2.40 The annual efficiency of the boilerhouse plant needs to be obtained by whatever means is preferred. Guidance on the measurement of boilerhouse efficiencies is given in Chapter 7, which also includes default values which may be used in the absence of calculated values.

2.41 Where a boilerhouse comprises mixed boiler types, the overall efficiency should be weighted in respect of relative annual outputs.

Step 8: DHWS load

2.42 The total volume of water consumed at the site needs to be quantified (from readings taken from the main meter), and that which is used for DHWS identified.

2.43 The volume of the water used for DHWS needs to be measured. Meters can be fitted into the cold water feed of the calorifier prior to the survey, the number required depending on the nature of the site. The time and expenditure involved in fitting such meters is worthwhile, as they will produce more accurate and reliable data. In the absence of measured data, a default value for DHWS of 40% total site cold water consumption may be used. The temperature difference across the calorifier will also need to be recorded.

2.44 The energy requirement for DHWS and the corresponding load on the boilerhouse are calculated using the formulae on Form 4. The result may then be plotted onto the graph of energy consumed against degree days to show how it forms part of the baseload.

Step 9: Ancillary steam load

2.45 In order to assess the ancillary steam consumption that contributes to the baseload, list all plant and equipment that

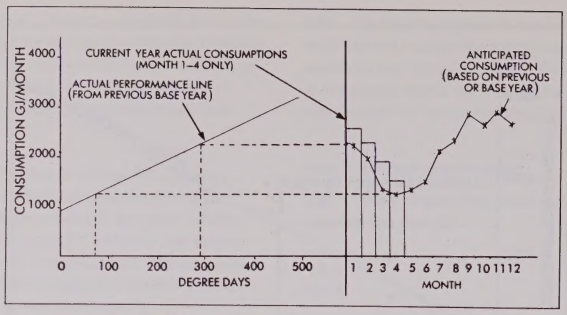

CONSUMPTION GJ/MONTH
4000
3000
2000
1000
CURRENT YEAR ACTUAL CONSUMPTIONS (MONTH 1–4 ONLY)
ACTUAL PERFORMANCE LINE (FROM PREVIOUS BASE YEAR)
ANTICIPATED CONSUMPTION (BASED ON PREVIOUS OR BASE YEAR)
0 100 200 300 400 500
DEGREE DAYS
1 2 3 4 5 6 7 8 9 10 11 12
MONTH

Figure 6 Anticipated monthly fuel consumption

uses steam; Form 5 will assist in this. If the boilerhouse supplies a laundry, its steam consumption must be included. (Chapter 7, Table 6 includes some typical steam consumption values for various items of equipment and plant, and Table 7 quantifies laundry steam consumption.)

2.46 From the total figure calculated, the energy requirement in GJ/month can be deduced using an average boiler enthalpy rise of 2304 kJ/kg of steam according to the formula on Form 4. This calculation is recorded on Form 4.

Step10: Circulation and distribution losses

2.47 The magnitude of distribution and circulation losses (which are calculated as a percentage of average monthly consumption) largely depends on the nature of the site. Typical values are given in Chapter 7, Table 8.

Step 11: Total assessed baseload

2.48 By totalling individual baseload components an assessed baseload may be calculated. The component and actual baseloads may now be depicted graphically as shown in Figure 7.

Step 12: Assessed space heating performance

2.49 Finally, the assessed heating performance needs to be calculated and superimposed on the performance graph. This calculation requires the following:

(i) itemisation of all the buildings supplied by each boilerhouse together with their heated volumes. (The details are entered on Form 6, using a separate form for each boilerhouse);

(ii) selection of a heat loss/unit volume (from Chapter 7, Table 9) for each building according to the type of construction, ceiling height and percentage glazing.

2.50 From the values on Form 6, the heat loss (in kW) is calculated for each building and each boilerhouse in aggregate. The assessed space heating factor can then be evaluated from the equation given on Form 6.

2.51 The result provides the slope of the assessed performance line, which should intersect the vertical axis where it meets the assessed baseload line. See Figure 8.

Step 13: Performance analysis

2.52 Having constructed the actual and assessed performance lines for both the baseload and space heating elements, Figure 8 should now be analysed in detail. Interpretation of this graph by the engineer improves with practice and experience and is essential.

2.53 The following points should be examined:

a. excessive scatter of the points about the actual performance line. This can be caused by:
   (i) poor performance of the space heating controls;
   (ii) inaccurate fuel monitoring;
   (iii) changes in the heated volume on the site;
   (iv) temporary shutdown of plant;

b. the proportion of the baseload associated with circulation and distribution losses, DHWS consumption and ancillary steam use. Comparison of these may help corroborate the estimated figures;

c. the difference between the actual and assessed baseload. Ideally, these should be the same, indicating that all the baseload consumption can be accounted for. In practice, however, a gap between the two lines will be evident. The difference may be due to overheating in mild weather, actual room temperatures being higher than allowed for by the DD base temperatures, or simply the inaccurate recording of fuel consumption. A simple method to corroborate the energy consumption attributable to the baseload is to ensure that all heating services are shut off and actual consumption is metered at the boilerhouse. This assumes that the boiler plant can respond to the changed load at a similar level of efficiency. July and August boilerhouse loads are often taken as indicating the baseload;

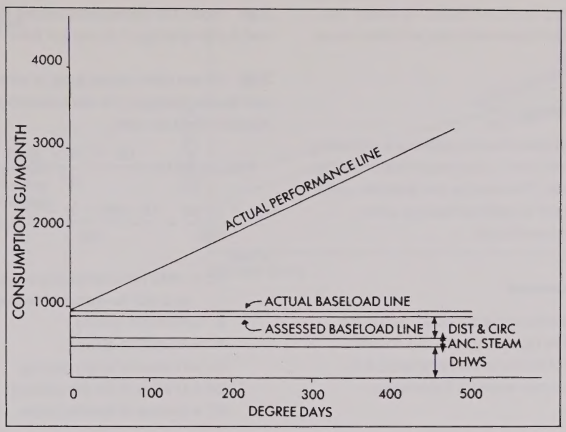


Figure 7 Actual and assessed baseloads

d. the relative slopes of the actual and assessed space heating performance lines. Figure 9 illustrates the ways in which these lines can diverge, and suggests possible reasons for such discrepancies.

Support material

2.54 Computer programs: Enmats;
Encap;
Enbuild;
Enplant.

Assessment of site energy requirement

2.55 The purpose of this section is to make a much more accurate assessment of the site boiler fuel requirements than in the previous section.

2.56 The space heating requirements are calculated for each building taking full account of its construction, usage and occupancy.

2.57 The baseload assessment is the same as that described in the previous section, but using accurate, measured data in place of norms or best estimates. A balance sheet of actual fuel consumption compared with the assessed consumption is produced. The difference will indicate the potential savings for the site.

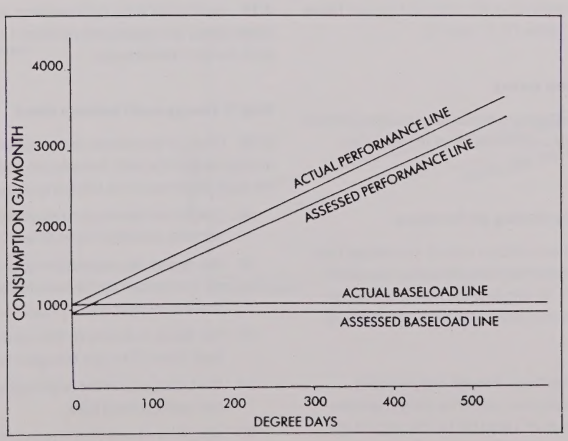


Figure 8 Actual and assessed performance

2.58 The accompanying flowchart (Figure 10) shows that assessment of site energy requirement may be broken down into the following steps.

Step 1: Boilerhouse survey

2.59 A survey is undertaken of each boilerhouse, according to the criteria specified on Form 7: a separate form should be used for each boilerhouse. (This exercise also provides useful information for assessment of potential savings when improvements are being considered.)

Step 2: Re-assessed baseload

2.60 The method of assessing the baseload used in the previous section should be repeated, but using accurate measured data in place of norms or best estimates; it is essential to derive an accurate value for boilerhouse efficiency.

2.61 The information is recorded exactly as in steps 7 to 11 above, but Form 8 is provided to emphasise the difference in accuracy of the two methods.

Step 3: Building survey

2.62 The buildings on the site should be fully surveyed. It should be ascertained that the heated volumes used in the previous section were obtained from a reliable source and that they are accurate. If they are not reliable, or if the prescribed procedures were not followed, heated volumes should be accurately measured using the method described in Chapter 7.

2.63 Similarly, external wall, roof and ground floor areas must be taken from reliable estate records, or measured. A Form 9 should be completed for each building.

2.64 U values for the external walls, roofs and ground floors are given in Chapter 7, Tables 10, 11 and 12.

Step 4: Heating systems survey

2.65 The results of this survey (one for each building) should be recorded on Form 10A, with a sketch of the layout on Form 10B.

Step 5: Assessed space heating performance

2.66 Using the details recorded on Form 9, the annual heat loss for all elements and each building should be calculated and entered on Form 11. To calculate the heat loss through the building fabric, reference should be made to Figures 20 to 23.

2.67 To calculate the heat loss through any particular element, the correct nomogram should be chosen and the heat loss factor (GJ/annum m^2) read off for the percentage glazing and fabric U value recorded.

2.68 **Note:** the nomograms assume fixed U values for single and double glazing – 5.6 and 3.4 $W/m^2°C$ respectively.

2.69 Where other values apply, or where there is both single and double glazing in the same building, the following equation must be used:

$$\text{heat loss factor} = \frac{DD \times 24 \times 3600}{10^9}\left[\frac{X \times Us}{100} + \frac{Y \times Ud}{100} + \frac{Uf\ (100 - X - Y)}{100}\right] \text{GJ/annum m}^2$$

where

DD = 3448 for hospital degree days
or 2462 for standard degree days;
X = % single glazing;
Y = % double glazing;
Us = U value of single glazing;
Ud = U value of double glazing;
Uf = U value of building fabric.

2.70 Heat losses through the floor and due to ventilation are quantified in Chapter 7, Tables 12 and 13, while the intermittent heating factor may be selected from Table 14 according to the building's construction, occupancy and plant response rate.

2.71 Finally, this heat loss assessment needs to be adjusted for local weather conditions. It should be divided by the national average value of the degree days used in the equations and nomograms (3448 or 2462 DD) and multiplied by the boilerhouse heating season degree days recorded on Form 1.

2.72 Note the exclusion of months when heating is turned off.

Step 6: Building heat loss summary

2.73 Heat losses from each building, as calculated in the above steps, are aggregated on Form 12, using a separate form for each boilerhouse.

Step 7: Energy audit balance sheet

2.74 Form 13 should now be completed to produce the energy balance for each boilerhouse and the whole site. For each boilerhouse the following steps are required:

(i) the annual baseload is calculated by multiplying the monthly baseload (Form 8) by 12;

(ii) the degree day adjusted heat loss is taken from Form 12 and divided by the boilerhouse efficiency to obtain the annual heat load;

(iii) this figure is divided by the annual boilerhouse degree days (Form 1) to give the space heating factor;

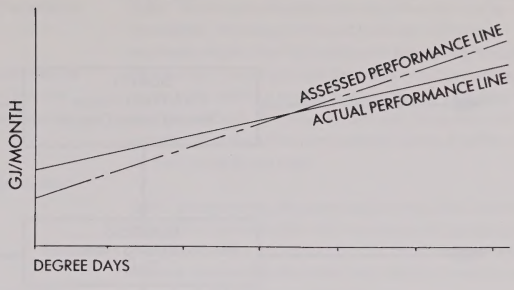
(iv) the baseload and the heat load are aggregated to give the total assessed load;

(v) actual consumption is entered from Form 2;

Performance lines crossing

Possible Reason

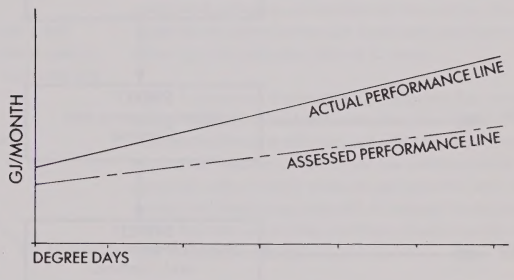
Poor control with possibility of summertime overheating and/or winter underheating



Performance lines diverging

Possible Reason

Energy losses increase in proportion to throughput
or
reasonable control but at too high a temperature
Low boilerhouse efficiency



Performance lines parallel

Possible Reason

Baseload component error.

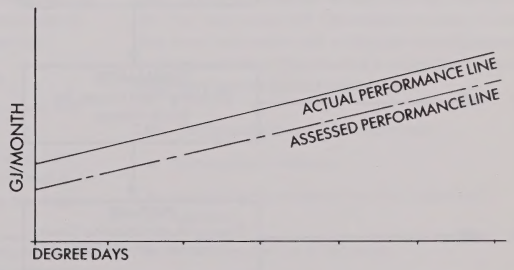


Figure 9 Interpreting relative performance

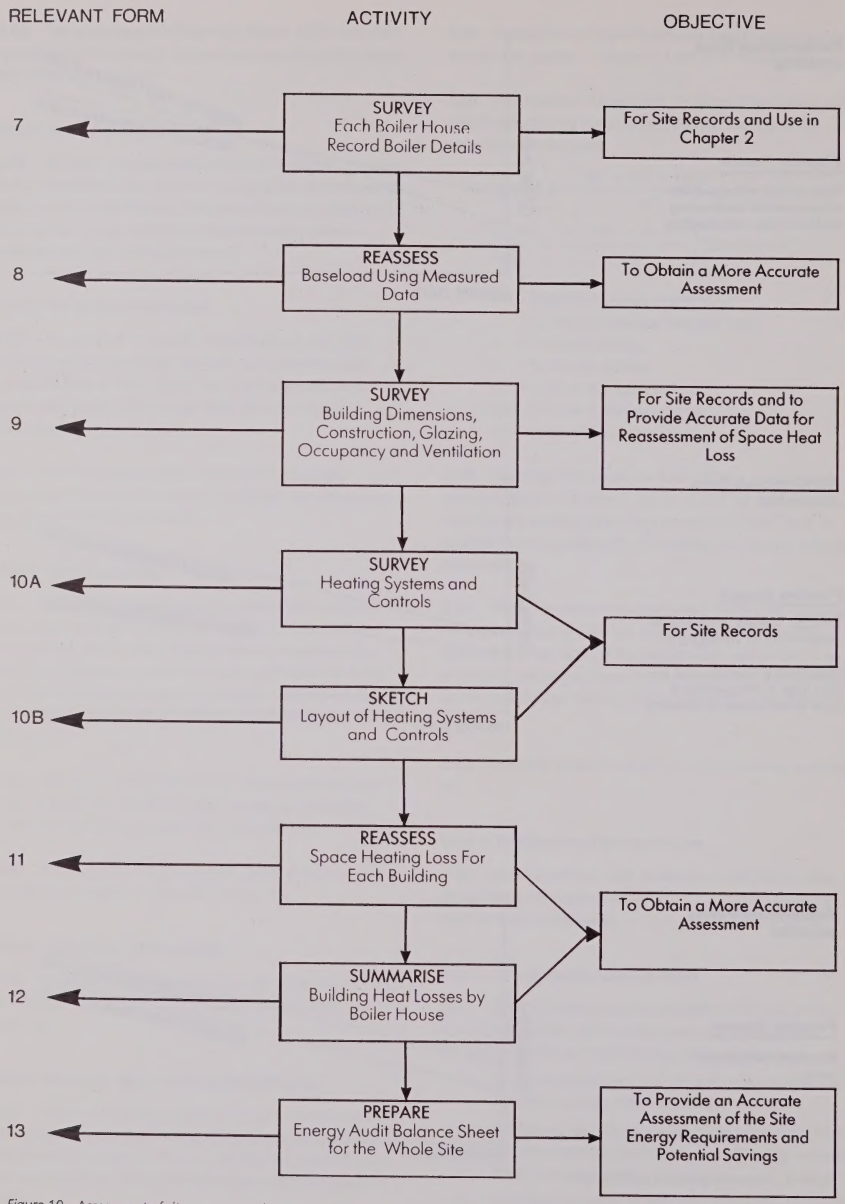


Figure 10 Assessment of site energy requirement

(vi) finally, all values are aggregated to give the total for the whole site.

2.75 The separate electricity and gas assessments may be added to those of the boilerhouse on Form 13 to give the full site energy requirement, although not all headings on Form 13 will be appropriate to these fuels.

2.76 The potential saving is the difference between the actual consumption and the assessed load.

Step 8: Performance analysis

2.77 The re-assessed space heating characteristic and baseload can be superimposed onto Figure 8 to give Figure 11 below.

2.78 The performance analysis carried out in the previous section can now be repeated with more confidence. The worked example in Chapter 8 illustrates this.

2.79 The method used in this section will provide a well documented set of detailed site records which can be used for more effective energy management of the site, both now and in the future.

Support material

2.80 Enbuild;
Enplant;
Enaudit;
CIBSE Guide.

Assessment of potential savings

2.81 The whole purpose of the ESAM procedure is to identify potential energy savings. Once identified, a logical method of implementation is needed. This section outlines a procedure for reducing the energy required for space heating, DHWS and ancillary steam, leading to a similar reduction in distribution and circulation losses. The energy savings checklist in Chapter 5 may also be useful.

2.82 The accompanying flowchart (Figure 12) shows that there are two areas of potential energy savings:

(i) good housekeeping – many savings will result from good housekeeping measures, which are aimed at improving existing plant and buildings so that they perform as designed or intended;

(ii) capital investment – the ESAM procedure provides the energy manager with an opportunity to examine the site and plant objectively and in greater detail than may be otherwise possible. This may highlight areas with energy-saving potential which, in turn, may require adjustments to capital expenditure levels.

These are discussed below.

2.83 The impact of estate rationalisation must also be considered. The change of use of buildings can have a profound influence on the selection of energy-efficient plant, for example it may no longer be necessary to have a large steam main serving a remote building when a local plant may be more efficient. This in turn could raise the question of whether plant should be decentralised, having a further effect on fuel contracts and costs.

2.84 Energy-saving measures must be evaluated, however, before the implementation of an energy-saving programme is carried out. This is important since the measure considered may not be economically viable; such decisions need to be made at the planning stage (Chapter 3).

2.85 It should also be recognised that incorrect assumptions in the previous two sections could affect the difference between actual and assessed performance. In the absence of information to the contrary, any potential savings which appear to be excessively high or low may suggest that the assessments are worth re-examination. In particular, this applies to circulation/distribution losses and boilerhouse efficiency, which are often difficult to assess.

2.86 Furthermore it is important to recognise that energy-saving measures interact with each other. For example, improved boilerhouse efficiency will affect the savings made by all other measures carried out on the buildings served by it. Hence the order in which measures are evaluated, and their savings calculated, is very relevant. If measures are not carried out in the most logical order, it will be necessary to back track and re-assess the effects.

2.87 It may therefore be helpful, after evaluating each action, to redraw the performance graphs and produce a new balance sheet in order to decide the next step.

Good housekeeping

2.88 Good housekeeping measures may be undertaken by both "lay" and estate staff. The initiative, however, is most likely to rest with estate staff, as they are primarily responsible for energy use. Form 15 is provided to record the measures under consideration for each boilerhouse.

2.89 The opportunities for lay staff include:

- turning down radiators;
- preventing the escape of heat from doors and windows;
- controlling the use of hot water;
- turning off cooking appliances when they are not needed.

These are all low cost measures incurring negligible expenditure after initial promotion, training and indoctrination costs have been met.

2.90 The activities of estate staff are more technical and will attract some material and labour charges. However, these need not necessarily be very high and should mostly be containable within the estate revenue or planned maintenance budgets.

2.91 Opportunities include:

- a reduction in air infiltration, achieved by draught stripping doors and windows. Where acceptable, door closers can also make a significant contribution to comfort as well as economy;
- reduction of room temperatures in non-clinical areas. Government regulations set out the maximum temperatures for these areas, which can be used as the criteria for resetting controls;
- re-scheduling space heating controls by adjusting or replacing incorrectly set or faulty clocks, thermostats, steam, mixing and diverting valves (settings may be out of date).

2.92 Having evaluated the savings from these and any other measures, a new space heating load and baseload may be calculated so that it can be decided whether or not capital investment measures are justified.

Capital investment

2.93 In the previous two sections, boilerhouse efficiency was examined closely; it is now proposed that improvements be sought. These could include:

- an improvement in burner heat release by burner change, re-bricking the combustion chamber or by steam injection;
- a reduction in blow down by a change of water treatment or automation;
- re-scheduled boiler run sequence with load.

Form 16 is provided to record details of the improvements and their effects.

2.94 Capital investment measures may also include improvements to buildings. In many buildings the fabric is lightweight, especially in those post-World War II hospitals where thermal insulation was a low priority. Where an upgrading is contemplated, the new U value must be calculated and the associated heat loss factor found using the information in Chapter 7.

2.95 Similarly, buildings with mechanical ventilation should be examined to identify measures which could reduce infiltration and exfiltration losses and optimise fan power. The new air change rate should be calculated and the associated heat loss factor noted. The revised space heating load may then be calculated and the savings found, using the formulae on Form 17.

2.96 Finally, improvements may be made to controls. Where there are extensive changes to these or where new systems are installed, the saving may be calculated (again on Form 17). This may be done independently of any building improvements.

2.97 All savings in fuel consumption resulting from capital investment measures can be summarised on Form 18. The revised potential baseload, heating load and total consumption can be calculated for comparison with actual consumption derived in the site energy performance analysis.

2.98 Total energy savings from both good housekeeping and capital investment measures for all boilerhouses are transferred to Form 19 and the cost savings evaluated. The worked example in Chapter 8 illustrates this. These measures should now be subjected to detailed investment appraisal to establish their financial viability and a programme of work prepared as described in Chapter 3.

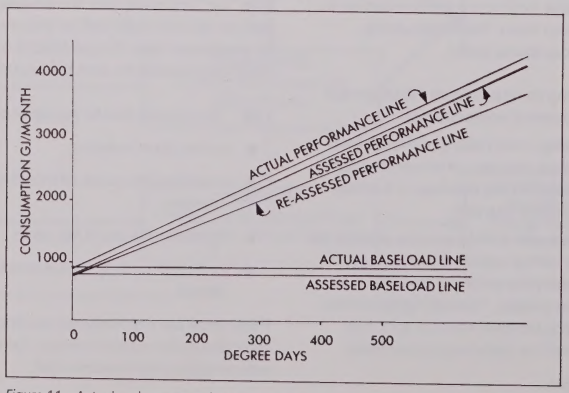


Figure 11 Actual and re-assessed performance

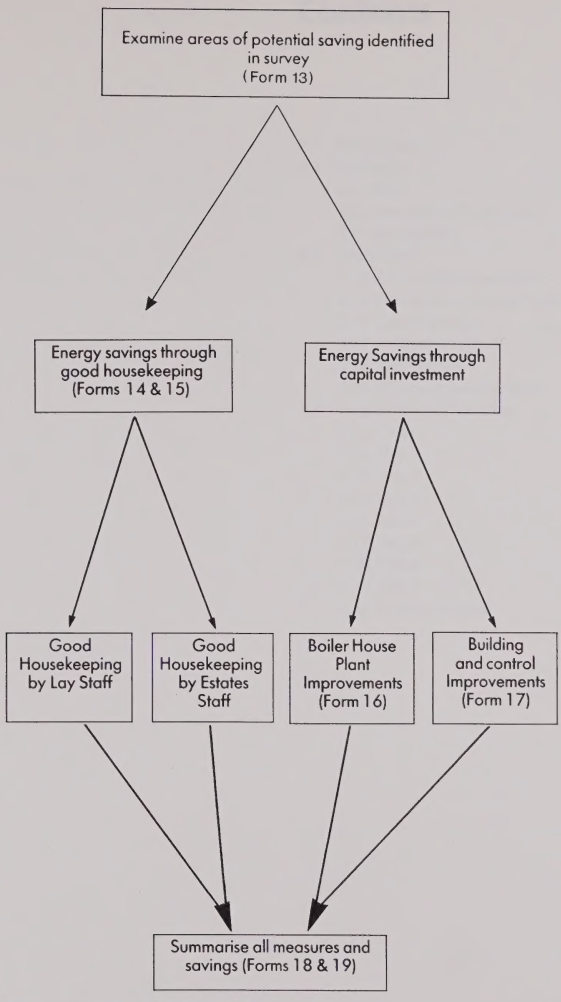

Examine areas of potential saving identified in survey (Form 13)
Energy savings through good housekeeping (Forms 14 & 15)
Energy Savings through capital investment
Good Housekeeping by Lay Staff
Good Housekeeping by Estates Staff
Boiler House Plant Improvements (Form 16)
Building and control Improvements (Form 17)
Summarise all measures and savings (Forms 18 & 19)

Figure 12 Assessment of potential savings

Energy strategy review

2.99 A review of the site is essential, since this can raise fundamental questions:

(i) is a central boilerhouse still required?;

(ii) can smaller boilers be used?;

(iii) are large steam mains with their associated losses still required: can steam be raised locally for Sterile Services Departments (SSDs), etc?;

(iv) what type of energy source is required and/or can a control unit be employed?

Support material

2.100 Encomp;
Encost;
Enbuild.

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3.1 Introduction
3.3 Promotion
3.4 Staff
3.5 Environmental conditions
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3.17 Additional costs
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3.0 Planning the programme

Introduction

3.1 In planning the implementation of the energy efficiency programme a number of factors will require consideration:

- the main aim of the programme is to reduce expenditure on energy, so that the resultant savings can be used for better patient care and/or re-investment to achieve further improvements in energy performance;
- the weight each factor carries will vary according to the district, unit or hospital;
- the programme should reflect local circumstances, priorities and resources; as these change, the programme may need to be modified;
- a programme will be easier to modify if it is well planned and documented in the first place;
- all measures taken will need to comply with relevant standards and procedures applicable to the district, unit or hospital concerned.

3.2 If the programme is not accepted before implementation, a high failure rate can be expected. Acceptance is more likely if those affected are involved in the overall cost-saving exercise, are aware of the aims and expectations of the programme, and feel part of the scheme rather than just its victim. Once again, it is important that the procedures for reporting problems are made clear so that occupants feel that they have control over their circumstances.

Promotion

3.3 The greater the commitment to the concept of energy efficiency within the district, unit or hospital, the more effective the programme is likely to be. It is therefore important to consider how best to promote the plan throughout the organisation to obtain maximum participation.

Staff

3.4 Participation of staff at departmental level is important for a number of reasons. Such individuals:

- know how the department works;
- may have ideas of their own on how savings can be made;
- can point out false assumptions which may be made by outsiders;
- can be the most effective people to introduce, and maintain, good housekeeping measures;
- can spot problems quickly as they occur and report them.

Thus the encouragement of departmental staff to participate in the energy efficiency programme is potentially the most effective single measure that can be carried out.

Environmental conditions

3.5 The effect of the programme on environmental conditions may be a crucial factor in its success.

3.6 A very successful method of reducing consumption is to lower heating, lighting and ventilation levels. However, if this produces conditions unacceptable to the occupants, these measures are likely to be short-lived and the instigator may lose both the saving and his/her credibility.

Management

3.7 At senior management level, the plan should be integrated into the estate investment programme. This will ensure that as the estate is rationalised, increased funds are available to raise its energy performance to a satisfactory level. Energy efficiency should form an integral part of unit performance reviews and target setting exercises.

3.8 It is important that good energy performance is not regarded as solely a function of the estates department. General management should share in the initiative for driving the energy improvement programme forward. This can be done by:

a. setting up energy review procedures and agreeing with the estates department the targets to be achieved;

b. demonstrating to department staff that while general management is committed to energy efficiency they also have an important role to play, particularly in the promotion of good housekeeping;

c. ensuring that the cost of wasted energy is known to staff and they are encouraged to contribute to its reduction.

Information

3.9 The first step in planning the programme is the gathering of information. Chapter 2 provides a recommended method of collecting data on energy consumption and identifying cost-saving measures, data which should be recorded on Form 21. In addition, a list of possible measures indicating likely departmental involvement, approvals necessary, and guidelines on timing, is given in Chapter 5 at Table 1.

Cost of implementation

3.10 This cost may be affected by timing and integration with other work. For example, it may be uneconomic to increase insulation to an existing flat roof, but if the roof needs to be replaced, the cost incurred could well be justified.

3.11 Similarly, double glazing may be cost-effective if windows are being replaced because of decay, though it may not be economically viable on energy conservation grounds alone.

Interaction of saving measures

3.12 Energy-saving measures may interact with one another. If a building is heated 24 hours a day, additional insulation may be viable. However, the same building heated intermittently may not justify the extra expense. Thus the fitting of zone controls, for example, to reduce the heated hours may make further insulation uneconomic.

3.13 Similarly, a building heated by high-cost electricity may benefit from additional insulation and tighter control of the time/temperature relationship, whereas the same building heated by a lower-cost fuel may have less stringent requirements.

3.14 When carrying out a number of measures it is important to determine their interaction, otherwise wildly over-optimistic predictions can be made.

Cost of energy

3.15 The actual and relative cost of different fuels is dependent on many factors. While it is impossible to predict accurately what the cost of any fuel will be in the future, a judgment must be made on its likely cost during the lifetime of the measure. For measures with a short pay-back period this may not be too difficult; for longer periods, sensitivity analysis may be necessary.

3.16 Use of different fuels and the availability of storage facilities can, however, maximise market opportunities by the judicious timing of fuel purchases. Furthermore, in a strategic sense (that is, in the event of a national fuel crisis), the flexible use of fuels and equipment is likely to be very important to the operation of the building.

Additional costs

3.17 Energy-saving measures, particularly heat recovery, may incur additional costs. For example, the heat recovery plant on laundry equipment may require frequent cleaning, while waste heat boilers may have a high maintenance cost in relation to their benefit. These additional costs need to be set against revenue savings when judging viability.

Expected life

3.18 The effective life of a measure may be determined by the life of the building or its use in its present form, or it may be inherent in the energy-saving equipment itself.

3.19 Building management systems have a finite life and if not upgraded can rapidly become obsolete.

Effects on building fabric

3.20 Care must be taken to ensure that damage does not occur to buildings, equipment, materials, etc as a result of carrying out energy-saving measures. When reducing temperatures or increasing insulation, the possible effects of condensation and freezing need to be considered:

- additional roof insulation could cause condensation, thus inducing rot, or cause freezing of pipes and tanks in a now colder roof space;
- too low a temperature at night might adversely affect computers and office equipment.

Programming of resources

3.21 Having gathered the information on energy-saving measures and energy performance, the task of selecting which measures to implement, in what order, and how to finance them begins; first, however, a detailed investment appraisal is essential. Some measures can be carried out by estates staff on their own initiative, while others may need integrating into other programmes.

Order

3.22 A suggested sequence of steps is provided below.

Step 1

3.23 Carry out measures incurring little or no cost, for example:

- reset time clocks (BST or GMT);
- reset thermostats (ESAM techniques may indicate overheating or a fault may have been reported).

Step 2

3.24 Carry out maintenance tasks, for example:

- replace faulty time clocks and thermostats;
- ensure boilers and heat exchangers are clean;
- repair or replace defective steam traps;
- replace removable lagging boxes for valves, etc;
- ensure that the planned maintenance system checks these items in future;
- eliminate leaks.

Step 3

3.25 Set up hospital energy review group to promote good housekeeping.

Step 4

3.26 Check the major maintenance programme. Is there work planned in which energy-saving measures can be incorporated, for example:

- is a domestic hot water calorifier due for renewal?;
- is hot water consumption low and intermittent? If so, installing point-of-use water heaters may be cheaper in initial cost and maintenance, while reducing distribution losses and revenue costs.

The high price of electricity may reduce savings, however.

Step 5

3.27 Check capital programme for similar opportunities that may arise during upgrading works.

Step 6

3.28 Set energy consumption target for individual buildings and plan a programme to bring energy performance to a condition consistent with the requirements of Estatecode.

Step 7

3.29 Incorporate the energy programme into the overall investment plan.

3.30 At this stage the number of proposals may exceed the identified resources for carrying them out. A review of resources will therefore be necessary:

- does the unit, district or region have an energy conservation fund?;
- is money available for revenue saving schemes?;
- is non-recurring money available, or will it be at the end of the financial year?;
- is it possible to have brokerage schemes to pay for short pay-back measures?;
- are there savings from previous savings schemes?;
- is a short-term fall in fuel prices likely?

3.31 Astute treasurers should be prepared to invest in short-term pay-back schemes in the first year, and then re-invest in longer-term saving in subsequent years.

3.32 Having produced a programme of planned investment and expected returns, the widest possible discussion should take place.

3.33 The purpose of this discussion is to secure commitment to the concept of investing now for the future and to ensure that valuable NHS resources are not squandered, or energy wasted, unnecessarily.

Support material

3.34 Estatecode;
Encode 2;
Encomp;
Encost.

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4.5 Issues ensuring effectiveness
- 4.5 Site energy master file
- 4.6 Improved data
- 4.7 Site changes
- 4.8 Monitoring
- 4.10 Performance indicators

4.14 ESAM
4.16 Building management systems
4.17 Metering
4.18 Support material

4.0 Monitoring and measuring effectiveness

Introduction

4.1 This section assumes that ESAM will be the standard method adopted for determining potential energy savings. It is nevertheless recognised that other methods are available and some have already been employed. Under these circumstances the process described below should still be used, with the knowledge that the procedures can be adopted retrospectively to confirm or amend earlier findings.

4.2 The energy survey, audit and resulting proposals for reducing consumption and cost, represent a significant first step, providing the basis for energy targeting and management.

4.3 Over time, many of the factors which determined the resulting investment programme are likely to change. Hence it will be necessary to review regularly and update the audit, the survey conclusions and the investment programme. In any event, a review of energy-saving possibilities should be undertaken each year.

4.4 The Enmats computer program provides a continuous month-by-month assessment of actual and targeted energy use, and can indicate areas where savings might be made.

Issues ensuring effectiveness

Site energy master file

4.5 The ESAM report is the first element of a site energy master file which is supplemented by:

a. a summary of the relevant effects of the authority's strategic plan for the site and its anticipated life;

b. the proposed site investment programme;

c. a log of changes to the site and amendments to the basic data;

d. annual monitoring and revision of relevant data;

e. annual and strategic targets.

Improved data

4.6 ESAM data may be subject to discrepancy. An unexplained imbalance between assessed and actual energy used would be indicative of error and should encourage efforts to devise improvements. In any event, constant monitoring is essential and this will generate data to either confirm or refute previous results.

Site changes

4.7 Site changes may include any, or all, of the following:

- proposals identified by ESAM or elsewhere which have been implemented;
- other site developments with relevance to energy consumption, for example additional buildings, modifications, disposals, changes to engineering plant and equipment, change of accommodation use. These changes arise in three forms:
  - (i) planned change;
  - (ii) changes created outside the formal planning system;
  - (iii) revisions of future plans;
- changes in the availability of fuel, or in the relative price of different fuels;
- innovations for conservation.

Monitoring

4.8 There are several tools available for monitoring energy management, and the choice will be subject to the following:

a. site factors, for example complexity, distribution and control of building services and plant;

b. site potential;

c. operational policies.

4.9 These factors interact with the monitoring objectives which may include:

- audit valuation to confirm or acquire more reliable data for the energy audit;
- proving savings – checking the savings achieved from specific schemes;
- operational monitoring – identifying unplanned and unexpected deviations.

Performance indicators

4.10 The evolution of the NHS estate has resulted in an extremely wide variation of energy efficiency standards from site to site. Performance indicators (PIs) may be used to quantify this variation defining a standard against which each site may be compared. They express the annual site energy consumption in GJ per 100 m^3 of heated volume under standard conditions.

4.11 While there may be legitimate reasons why particular sites have higher or lower efficiencies, or are unable to improve performance within acceptable returns on investment, the use of PIs is a good starting point for analysing and understanding variations in performance.

4.12 The accompanying flowcharts (Figures 13 and 14) summarise the steps necessary to calculate the normalised performance indicators for:

(i) Fossil Fuel (FPI);

(ii) Electricity (EPI).

4.13 The process of normalisation (ie, correcting for local variation so that performance may be related to standard national conditions) is as follows:

a. adjustment for type of use – NHS sites are typically used for a variety of purposes providing accommodation for true "hospital" use (that is, wards, theatres, etc), laundries, staff residences, student training, etc. To account for this, PIs are based on energy use for hospital accommodation only, and energy consumption attributable to all buildings or parts of buildings that are used for other purposes should be deducted where possible;

b. adjustment for weather conditions – energy consumption for space heating is related to local weather conditions. This is taken into account by relating performance to national standard degree days:

(i) calculate the energy consumption for space heating only (that is, excluding the baseload), and multiply this by

$$\frac{3448}{DD}$$

where DD is the actual degree days for the site and year under consideration;

(ii) 3448 represents 20-year national average degree days. For comparison on a district or regional basis, use 20-year average for the degree day area containing the site;

c. adjustment for site exposure – energy consumption for space heating is also related to site exposure. To correct for this, multiply the degree day corrected space heating consumption by an exposure factor as follows:

(i) sheltered. This site is in a built-up area surrounded by other buildings of equal or greater height. Exposure factor = 1.1;

(ii) normal. The site is on level ground in either urban or rural surroundings. Some trees and/or adjacent buildings are likely. Exposure factor = 1.0;

(iii) exposed. The site is on a coastal or hilly site with negligible screening. Exposure factor = 0.9;

Note that electricity is not normally used for space heating, so corrections for weather conditions and site exposure should be unnecessary when calculating the EPI. For completeness, however, the necessary steps are included in the flowchart;

d. add baseload;

e. correction for occupancy – while many sites are occupied 24 hours per day, seven days per week, some will only be used during working hours or on weekdays. To account for this, multiply the energy consumption by

$$\frac{8760}{HOURS}$$

where HOURS are:

(i) 8760 hours – hospitals, nursing homes;

(ii) 2600 hours – clinics, health centres;

(iii) 2300 hours – doctors' and dentists' surgeries;

Once the procedure described above and outlined in the accompanying flowcharts has been carried out, a single normalised PI can be calculated by adding together the FPI and the EPI:

NPI = EPI + FPI.

The NPI quantifies the total amount of energy consumed in each building in GJ/100 m^3 per annum under standard conditions; NPIs have been developed to take into account local and environmental factors;

f. performance yardsticks – calculation of the NPI enables comparison with other buildings using the performance yardsticks (for hospitals) below (all data is in GJ/100 m^3 per annum):

(i) "small acute" (<25,000 m^3). If total energy consumption (fossil fuel and electricity) is below 60, energy efficiency is good; a figure between 60 and 80 is fair, but over 80, poor;

(ii) "large acute" (>25,000 m^3). If total energy consumption is less than 70, efficiency is good; a figure between 70 and 80 is fair, but over 80, poor;

As yet, firm yardsticks for PEPIs have not been established. However, as an indication, a NPI of 70 equates to a PEPI of approximately 100. This assessment is based upon a FPI of 60 and a EPI of 10;

g. "Primary Energy PI" (PEPI) – this is similar to the NPI, but also takes the relative efficiencies of the fuels into account and hence provides a measure of efficiency in terms of primary resources used. The calculation is as for the NPI above, but with the energy consumption for each individual fossil fuel and electricity being multiplied by the corresponding primary energy factor, prior to correction for weather conditions and occupancy.

The primary energy factors currently being used are:

coal	1.0
gas	1.0
oil	1.0
steam	1.4
electricity	3.7

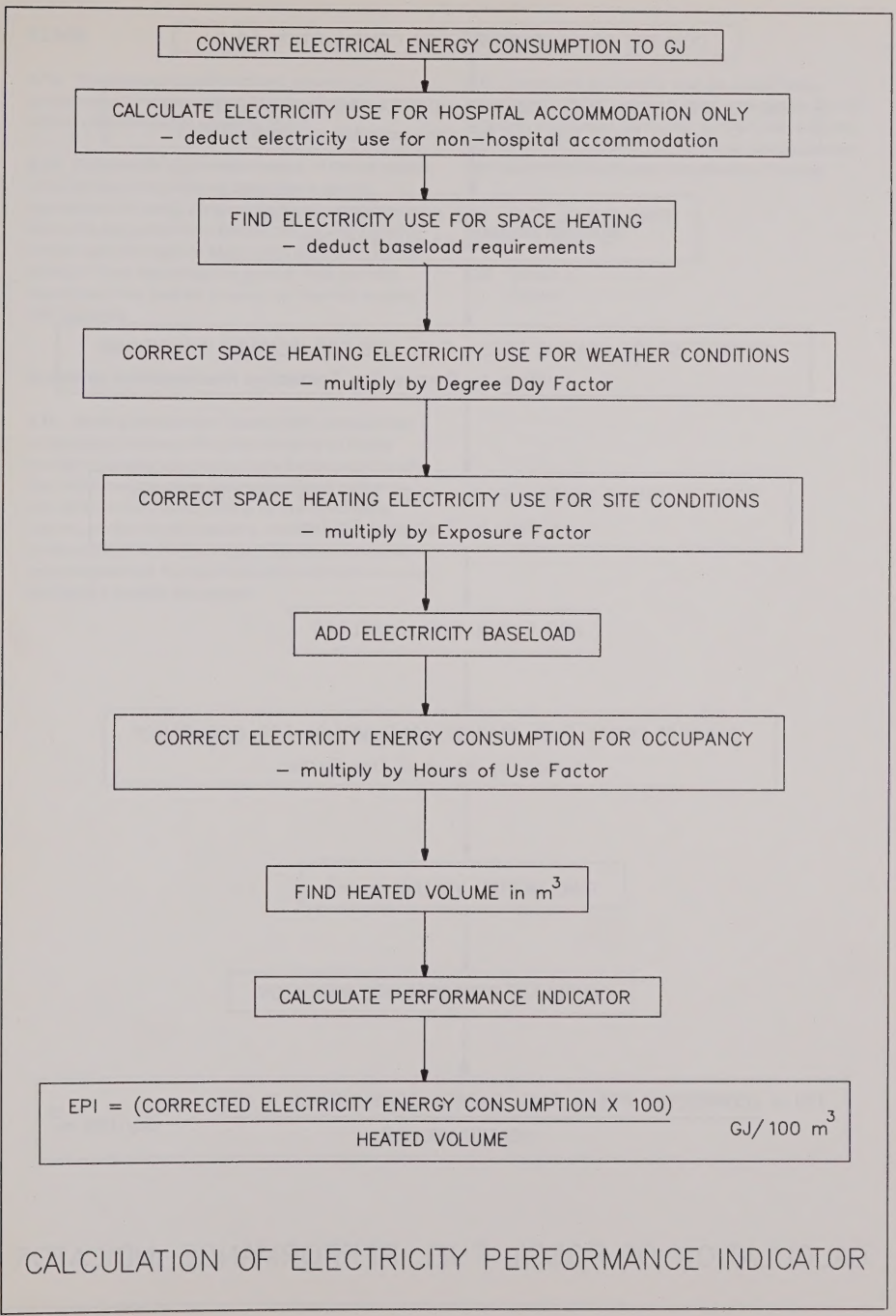
CONVERT ELECTRICAL ENERGY CONSUMPTION TO GJ
CALCULATE ELECTRICITY USE FOR HOSPITAL ACCOMMODATION ONLY
– deduct electricity use for non–hospital accommodation
FIND ELECTRICITY USE FOR SPACE HEATING
– deduct baseload requirements
CORRECT SPACE HEATING ELECTRICITY USE FOR WEATHER CONDITIONS
– multiply by Degree Day Factor
CORRECT SPACE HEATING ELECTRICITY USE FOR SITE CONDITIONS
– multiply by Exposure Factor
ADD ELECTRICITY BASELOAD
CORRECT ELECTRICITY ENERGY CONSUMPTION FOR OCCUPANCY
– multiply by Hours of Use Factor
FIND HEATED VOLUME in m^3
CALCULATE PERFORMANCE INDICATOR
EPI = (CORRECTED ELECTRICITY ENERGY CONSUMPTION X 100) / HEATED VOLUME
GJ/100 m^3
CALCULATION OF ELECTRICITY PERFORMANCE INDICATOR

Figure 13

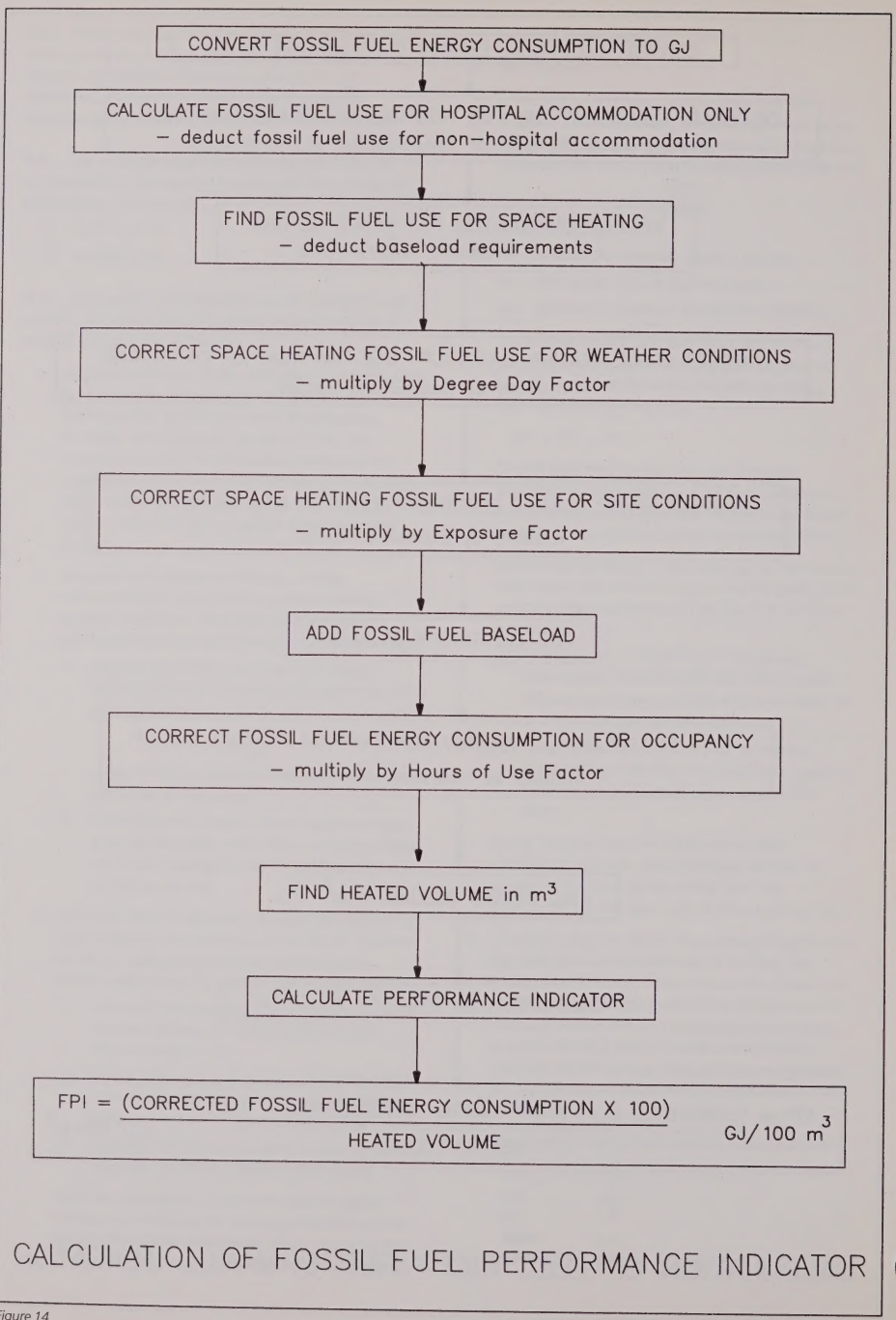
CONVERT FOSSIL FUEL ENERGY CONSUMPTION TO GJ
CALCULATE FOSSIL FUEL USE FOR HOSPITAL ACCOMMODATION ONLY
– deduct fossil fuel use for non–hospital accommodation
FIND FOSSIL FUEL USE FOR SPACE HEATING
– deduct baseload requirements
CORRECT SPACE HEATING FOSSIL FUEL USE FOR WEATHER CONDITIONS
– multiply by Degree Day Factor
CORRECT SPACE HEATING FOSSIL FUEL USE FOR SITE CONDITIONS
– multiply by Exposure Factor
ADD FOSSIL FUEL BASELOAD
CORRECT FOSSIL FUEL ENERGY CONSUMPTION FOR OCCUPANCY
– multiply by Hours of Use Factor
FIND HEATED VOLUME in m3
CALCULATE PERFORMANCE INDICATOR
FPI = (CORRECTED FOSSIL FUEL ENERGY CONSUMPTION X 100) / HEATED VOLUME
GJ/100 m3
CALCULATION OF FOSSIL FUEL PERFORMANCE INDICATOR

Figure 14

ESAM

4.14 The accuracy of the PIs and their relevance in comparing performance relate to ESAM itself, and to whatever data limitations applied to ESAM.

4.15 If successfully applied and analysed, ESAM will provide the information that limits and determines potential improvements in energy performance. This information is vital to the real performance analysis, and negates any other comparisons that might be drawn using national or regional averages. There may perhaps be other strategic planning impediments that frustrate progress, but these can be dealt with separately.

Building management systems

4.16 Building Management Systems (BMS) are essentially a management tool recording data for use by an energy manager. In addition to normal control features which justify their installation, the prime importance of such systems is their ability to monitor useful data, for example diversity patterns, environmental conditions, metered consumption, climatic conditions, etc. The range of options can be quite extensive given that the need to establish data patterns is not necessarily a constant requirement.

Metering

4.17 Inadequate metering facilities are a significant impediment to ESAM accuracy. Investment in this area should be actively encouraged, particularly in conjunction with BMS. Selectively sited sub-meters can provide valuable information with regard to the distribution and utilisation of energy.

Support material

4.18 Encode 2;
Enmats.

Contents

5.1 Introduction
5.3 Boiler plant
    5.3 Steam boiler plant
    5.4 Hot water boiler plant
5.5 Wet heating systems
5.6 Electrical heating systems
5.8 Combined heat and power
5.13 Laundries
5.14 Kitchens
5.15 Areas of infrequent use
5.17 Electric lighting and power
5.18 Ventilation
5.19 Refrigeration
5.20 Building fabric
5.21 Maintenance
5.23 Support material

5.0 Energy savings checklist

Introduction

5.1 The checks given below are designed to assist in the identification of energy savings. They comprise both good housekeeping and capital investment schemes. The list is not, however, intended to be exclusive or to be a substitute for the employment of a competent energy surveyor.

5.2 The table at the end of this section lists identifiable measures and indicates where specific expertise or approval is required for their implementation, together with guidance on timing.

Boiler plant

Steam boiler plant

5.3

a. what procedure is adopted to examine and check the quantity and quality of fuel?;

b. does an examination of daily log sheets, monthly summaries and/or annual reports indicate any significant change in the load pattern, output or efficiency?;

c. if significant variation (apart from normal seasonal variation) is indicated, can reasons for change be identified?;

d. where there are indications of disproportionate peak steam demand, can an analysis of load build-up improve efficiency?;

e. does analysis of load pattern/boilers on line indicate the potential for reducing the number of boilers during certain load conditions?;

f. can changes in thermal efficiency of each boiler be determined between the traditional 66% up to say 110% load? (This is to prove a case for a small overload over short periods, thus avoiding the need to bring on line an additional boiler.);

g. what procedures are in use to ensure correct functioning and calibration of boiler plant instrumentation? Is there scope for improved instrumentation which could lead to improved operational efficiency?;

h. from records of flue cleaning as against flue exit gas temperature, can the interval between cleaning be optimised?;

j. is steam boiler plant operated at minimum pressure conditions to satisfy all requirements? If pressure is greater than required, what would allow the plant to operate at lower pressure?;

k. what band width is operated for boiler pressure auto-controls? Is there a case for increasing the band width without detriment to the user systems?;

m. do the existing combustion control systems achieve the most efficient fuel/air ratios? Can improvements be made? (Cost-benefit analysis should be carried out.);

n. can an analysis of boiler blow down determine optimum efficiency? (High water treatment costs are indicative of faults in the system.);

p. have there been any significant changes in the records of condensate return temperatures from systems? If so, can reasons for change be deduced (for example faulty steam traps) and corrected?;

q. do records indicate any significant change in the ratio of steam generated to make-up water? Can improvements be made?;

r. what use is made by engineering management of operational data records?

Hot water boiler plant

5.4

a. what procedure is adopted to examine and check the quantity and quality of fuel?;

b. does an examination of daily log sheets, monthly summaries and/or annual reports indicate any significant change in load patterns and thermal/combustion efficiency?;

c. if significant variations (apart from normal seasonal variations) are indicated, can reasons for change be identified?;

d. what procedures are in use to ensure correct functioning and calibration of boiler plant instrumentation? Is there scope for improved instrumentation which could lead to an increase in operational efficiency?;

e. from records of flue cleaning as against exit flue gas temperature, can the interval between cleaning be optimised?;

f. do the existing combustion control systems achieve the most efficient fuel/air ratios? Can improvements be made? (Cost-benefit analysis should be carried out.);

g. if the boiler plant is operated manually, is guidance available to the "operator" on the effect of seasonal (external temperature) changes to boiler flow temperature?;

h. what use is made by engineering management of operation data records?

Wet heating systems

5.5

a. is the system balanced?;

b. where flow temperature is controlled manually, do "operators" have appropriate instructions for setting controls in relation to external weather conditions?;

c. what would be the cost benefit of fitting simple automatic control systems?;

d. in the case of systems with automatic control, do these function as intended? Do results indicate over-shoot or under-shoot? Could system capacity be reduced by throttling specific sections, radiators or convectors?;

e. in all cases of automatic or manual control installations, could time clocks be introduced to either isolate or throttle sections during unoccupied periods?;

f. in the case of thermostatic control systems with external compensation, are the ratio (slope) settings correct? (Where temperature records are available, they should be used to check correct functioning.);

g. in thermostatic control systems with night set-back and morning boost, are these operating as intended? Have the set-back time and ratio been correctly determined? Has the boost period been minimised? Would optimum start be advantageous in some areas?;

h. are all control systems with multiport proportioning/ injection valves functioning correctly on the right temperature ratio settings?;

j. in the case of vacuum steam heating systems, are all thermostatic control valves operating as intended? Is there a programme for routine checking and measurement of room temperature conditions?

Electrical heating systems

5.6 Both the relative cost and the polluting effect on the environment of electricity are three times greater than that of fossil fuels.

5.7 These ratios serve to underline the critical importance of using electricity efficiently; as a consequence, the following should be examined:

a. all off-peak electrical storage heating, for correct application of appropriate tariff;

b. all off-peak electrical storage systems, for optimisation of time clock control, programme settings and variability related to external temperature and comfort conditions;

c. all off-peak electrical storage systems, for correct operation of ratio controllers and external sensors;

d. all normal tariff installations (including individual "boost" electrical radiators and convectors), for appropriate use and possible application of time clocks and/or thermostatic control;

e. all heat exchangers, for regular cleaning and servicing.

Combined heat and power

5.8 Combined heat and power (CHP) units make use of a single, relatively low-cost, fuel (usually gas or diesel) to generate both heat and electricity. This provides an opportunity for optimising conversion of fuel and energy savings on site.

5.9 The units may be marginally less efficient than boilers, but this difference is more than offset by direct savings in electrical unit costs and, in some cases, maximum demand charges.

5.10 As the efficiency of CHP is much greater than conventional power generation, overall carbon dioxide emissions to the atmosphere are significantly reduced.

5.11 Most CHP installations on a hospital site can use a spark ignition or diesel engine where heat is recovered from the cooling water and exhaust gases. Very large sites may be able to accommodate a gas turbine, where the heat is recovered from the exhaust via a waste heat boiler.

5.12 To optimise the financial return, care should be taken to ensure the heat output is fully utilised.

Laundries

5.13

a. is there a procedure for shutting down all steam mains to laundry premises during non-production periods, and is this being applied? (Experience suggests that the shutting down of individual machines – closing of steam valves and tripping of isolating switches – at the end of each production period should be the responsibility of the laundry operational staff, but that the shutting down of all steam mains distribution systems serving the laundry premises should be the responsibility of the engineering staff. Similarly, a specific programme for system start-up and the heating up of machines can best be carried out by engineering personnel. The normal practice is to have the steam mains and individual machines brought slowly to full operational conditions just in time to meet the start-up of production. Such a procedure ensures maximum energy economy and the minimum delay in achieving full-scale production. It also avoids short-term, peak

load conditions which otherwise would be imposed on the central steam boiler plant with consequent reduction of operating efficiency.);

b. do the laundry ventilation/air heating systems have time clock control programmes? If so, are these correctly set; if not, would their installation be economic? Failing an immediate change to auto-control, can a manual system of shut-down and start-up be instigated?;

c. can time clocks be used for all ancillary accommodation services, heating, ventilating, lighting, etc?;

d. can steam and water usage be more efficient?

Kitchens

5.14 Dramatic savings can be made by catering staff simply by having appliances operating only when they are in use. Most hospital kitchens have a pattern of intermittent usage and a survey can often show the potential for energy saving by the introduction of time clocks for heating, ventilation, process steam mains, illumination, etc:

a. can steam-using equipment be operated satisfactorily and without detriment to user requirements on lower pressures?;

b. are items of gas-using equipment operating efficiently in terms of combustion and conditions? (Check for correct settings and operation of pressure governors, gas burner jets/orifices.)

Areas of infrequent use

5.15 These include: dining rooms, recreation rooms, day rooms, lecture theatres, seminar rooms, out-patient departments, operating theatres, offices, stores, laboratories, CSSDs, etc.

5.16 All these areas are usually used intermittently, some on a regular daily and/or weekly basis, others spasmodically:

a. in areas used regularly, appreciable energy savings can be effected by the introduction of time clocks and/or thermostatic controls to shut off or set back energy requirements during periods of non-use. A study of requirements can determine an appropriate programme (Consideration should be given to the installation of a control system such as the "Optimum Start" or similar.);

b. in areas of irregular use, specific individuals should be responsible for ensuring that the services are switched on and off as required;

c. time clocks with a fixed "on" period and which require the user to "opt-in" for any further predetermined period have been shown to be very energy-efficient.

Electric lighting and power

5.17

a. a study should be made of all non-critical areas where the installed level of illumination could be simply reduced, by the disconnection of selected fittings or by removal of one or two lamps from multiple tungsten fittings;

b. in the case of tungsten light fittings, wattage can very often be reduced without detriment to requirements, or low power economy lamps may be fitted;

c. in many instances, for example roads, car parks and general works areas, the introduction of time clock controls with solar dials can achieve appreciable reductions in electricity consumption. Localised time clocks can also be introduced to switch off power in those areas not in use overnight;

d. where the electrical circuiting precludes time clock control it may be possible to devise a programme of manual switching;

e. all central or group power factor correction equipment should be examined to ensure correct operation. Further study may also show a case for the introduction of such equipment with a quick return on capital investment.

Ventilation

5.18 Opportunities exist to recover heat from exhaust air, and preheat the incoming air by means of run-around coils, thermal wheels and plate heat exchangers. Recirculation systems could be considered for non-clinical areas. Heat pumps can also be used to extract waste heat but their financial viability should be carefully considered.

Refrigeration

5.19 Refrigeration systems used for air conditioning provide a potential source of heat recovery. Heat normally emitted into the atmosphere could be recovered by heat pumps or wet heat exchangers; the latter will only provide low grade heat.

Building fabric

5.20

a. window sealing and panel construction buildings should be checked to ensure that air infiltration is kept to a minimum;

b. insulation values for the building fabric should be evaluated using infrared photography to show areas of greatest heat loss;

c. where upgrading has taken place, for example rewiring, has all insulation been correctly refitted?;

d. can the existing insulation be increased economically? (Consider double glazing, especially when window or door replacements are due.)

Maintenance

5.21 Benefits obtained from heat recovery, control systems and energy-efficient design can be negated if the systems are not properly maintained.

5.22 It is recommended that all energy systems are monitored and that maintenance routines are incorporated into a planned preventive maintenance scheme by using the WIMS modules.

Support material

5.23 Health Building Note (HBN) 25, 1990 Edition, HMSO (for Scotland, Health Building Note (SHBN) 25).

Table 1 Identifiable saving measures

	Expertise needed for implementation		Needs approval of medics or others	Timing of improvement measure		
	M/E	D		Any time	With decoration	Upgrading/ modernising
Good housekeeping						
Lighting						
Ensure the efficiency of light sources by:						
keeping windows and rooflights clean	✓			✓		
siting workplaces near the light	✓		✓		✓	
keeping artificial lights clean	✓			✓		
replacing lamps with high efficiency lamps when, due to their age, efficiency has dropped	✓			✓		
re-decorating with light colours and choosing light furnishings to reflect light	✓		✓		✓	
using directional shades and diffusers	✓		✓		✓	✓
checking that lighting levels are not greater than necessary	✓		✓	✓		
switching off lights whenever they are not required	✓		✓	✓		
Space heating						
Check the settings of internal temperature controls	✓		✓	✓		
Reduce heating during non-working hours (subject to providing frost protection, condensation protection and suitable warm-up time)	✓		✓	✓		
Check windows are not opened unnecessarily during the heating season	✓			✓		
Ensure regular maintenance of heating equipment	✓			✓		
Ensure the best combustion efficiency by:						
checking flues are not blocked and have proper draught	✓			✓		
cleaning all combustion surfaces	✓			✓		
checking fuel/air ratios	✓			✓		
avoiding negative pressure in the room supplying combustion air	✓			✓		
Heat only occupied spaces but ensure unoccupied spaces are not subject to condensation		✓		✓		
Recalibrate controls to ensure correct settings	✓			✓		
Check that location of thermostats is correct	✓			✓		
Domestic hot water						
Reduce the water supply temperature to non-critical areas, ensure minimum required temperatures	✓		✓	✓		
Limit showers to a flow rate of 0.2 litres/sec (subject to there being suitable valves)	✓			✓		
Avoid dripping taps	✓			✓		
Shut down at night						
Ventilation						
Reduce fresh air leakage where possible, consistent with adequate standards of hygiene	✓			✓	✓	
Reduce mechanical supply and extract air quantities if excessive	✓		✓	✓		
Wherever possible reduce fan capacity		✓	✓	✓		
Clean and lubricate fans regularly				✓		
Seal air leaks in ducting	✓					✓

M/E: Maintenance/engineering experience D: Design expertise

	Expertise needed for implementation		Needs approval of medics or others	Timing of improvement measure		
	M/E	D		Any time	With decoration	Upgrading/ modernising
Air conditioning						
Check settings, avoid leaks and ensure a high system efficiency	✓			✓		
Ensure cooling and preheating do not take place together	✓			✓		
Equipment						
Switch off equipment when not required	✓			✓		
Building fabric options						
Walls						
Cavity insulation U foam mineral wool	✓			✓		
Solid wall insulation – external		✓		✓		
Solid wall insulation – internal		✓				✓
Block up air bricks behind radiators	✓					✓
Foil behind radiators	✓				✓	
Partition off unoccupied areas but maintain 10°C	✓			✓	✓	
Block off chimneys and ventilate	✓					✓
Windows						
Double glazing						✓
Sun shading to windows of air-conditioned areas		✓				✓
Draught stripping	✓			✓		
Reduce glass area and infill with insulated panel		✓	✓			✓
Heat resisting film on windows in air-conditioned areas	✓		✓			
Doors						
Draught stripping	✓			✓		
Fit automatic access doors		✓	✓			✓
Self-closing action with time delay		✓	✓			✓
Use rubber doors		✓	✓			✓
Install air curtains		✓				✓
Fit doors between spaces at different temperatures	✓		✓		✓	
Roofs						
Loft insulation (100 mm)	✓			✓		
Flat roof insulation – inverted roof		✓				✓
Flat roof insulation – other methods		✓				✓
Lower ceilings		✓				✓
Convert flat roof to pitched		✓				✓
Floors						
Premier insulation to new concrete ground slabs		✓				✓
Suspended ground floor insulation		✓				✓
Soffit insulation below exposed floors		✓				✓
Insulation to floors separating heated and unheated spaces		✓				✓

M/E: Maintenance/engineering experience D: Design expertise

	Expertise needed for implementation		Needs approval of medics or others	Timing of improvement measure		
	M/E	D		Any time	With decoration	Upgrading/ modernising
Engineering services options						
Boilers						
Improve combustion efficiency by:						
using waste heat to preheat combustion air		✓				✓
replacing old cast iron boiler with new package unit		✓				✓
Consider change of fuel to reduce costs						
Change from steam to MPHW distribution		✓				✓
Change to de-centralised rather than a central heat source		✓				✓
Use flash steam recovery from site condensate (to provide hot water)		✓				✓
Meter flow rate to calorifiers				S		
Provide local water heaters						
Emitters						
Replace electric night storage heater and resistance heaters with alternatives		✓		✓		
Controls						
Install a weather compensator control system (including motorised valves)		✓		S		
Install time controls where appropriate		✓		S		
Install an automatic energy management control system		✓				✓
Provide individual room/zone controls (for system already compensated)		✓			✓	✓
Control to depress flow temperature at night		✓		✓		
Optimum start/stop						
Pipework and valves						
Insulate heating pipework	✓			✓		
Insulate dhw pipework	✓			✓		
Insulate condensate main	✓			✓		
Insulate serviceable components	✓			✓		
Repair leaks in steam main and at valves, etc	✓			✓		
Fit spring loaded or spray taps to lavatory basins	✓	✓				
Replace furred-up pipework and check water treatment facilities		✓				✓
Ventilation						
Convert constant volume fans to VAV operation		✓				
Recover heat from ventilation air by:						
heat pipes		✓				✓
run-around coils		✓				✓
heat wheels		✓				✓
plate heat exchanger		✓				✓

M/E: Maintenance/engineering experience D: Design expertise S: Summer only

	Expertise needed for implementation		Needs approval of medics or others	Timing of improvement measure		
	M/E	D		Any time	With decoration	Upgrading/ modernising
Equipment						
Recover heat from:						
laundry wash water		✓				✓
incinerators		✓				✓
laundry tumble dryers		✓				✓
air-conditioning cooling fluid		✓				✓
Lighting						
Fit automatic timing controls		✓				✓
Alter switching zones to take account of lights near windows		✓				✓
Fit task/ambient lighting systems where possible		✓				✓
Change tungsten to fluorescent	✓					✓
Fit directional shades, diffusers, etc	✓	✓				✓

M/E: Maintenance/engineering experience D: Design expertise

Contents

6.1 Introduction
6.3 Survey, audit and investment appraisal programs
6.8 Enbuild, Enplant and Enaudit
6.19 Encost and Encomp
6.30 Data collection and analysis programs
6.34 Encap
6.38 Enmats

6.0 Computer programs

Introduction

6.1 A number of computer programs are available to complement the principal methods employed by Encode. These programs follow the procedures and techniques described in this manual and produce the same energy reports, but reduce the tedious and time-consuming calculations; they also provide greater flexibility for change and experimentation with energy-saving measures. Used in conjunction with Encode, the programs provide a complete energy management package which allows energy use to be continually monitored, assessed and improved. The programs also improve the understanding of how energy is used in buildings, highlight problem areas, and assist in controlling and subsequently reducing energy usage and costs.

6.2 The programs are available to the National Health Service through the Estate Information Consortium (EIC). They cover two principal areas:

(i) survey, audit and investment appraisal;

(ii) data collection and analysis.

Survey, audit and investment appraisal programs

6.3 Five programs are available:

(i) Enbuild: space heating energy requirements;

(ii) Enplant: baseload energy requirements;

(iii) Enaudit: energy audit;

(iv) Encost: investment appraisal of energy-saving measures;

(v) Encomp: comparison of energy-saving measures.

Comprehensive descriptions of each of these programs, together with detailed user instructions, are contained in the Encode software support manual.

6.4 The purpose of this section is to highlight the key functions of these programs; their use in support of Encode is also summarised on the accompanying flowchart (Figure 15).

6.5 The programs provide:

a. an attractive and easy-to-use interface employing screen forms and menus. The user is prompted to select from a range of options, or to enter data as appropriate. All input is fully validated to protect against typing mistakes and misunderstandings. Default values or "norms" are supplied, wherever possible;

b. comprehensive on-line help facilities giving guidance at any stage, at any time;

c. flexibility: all data can be readily changed while output can be directed to the screen, the printer, or to a file for subsequent word processing.

6.6 They will run on any IBM-compatible computer that supports the DOS operating system and has at least 512 kb of memory, a 10 Mb hard disk and a single floppy drive. They are written in Microsoft Basic (version 7) and have been compiled for greater speed. The Basic run-time system is issued with these programs, so no extra software is necessary.

6.7 The programs are distributed on IBM PC format 5.25" or 3.5" disks. On receipt of these it will be necessary to install the programs for the particular hardware configuration in use (display unit, disk drives and printer).

Enbuild, Enplant and Enaudit

6.8 The key functions of these programs are to:

a. support the Energy Survey and Audit Method (ESAM);

b. provide facilities to gather and record data on current and estimated energy usage;

c. build an energy "profile" of a site;

d. allow potential energy savings to be identified by comparison of assessed requirements with recorded usage.

6.9 **Enbuild** provides facilities to assess the boilerhouse energy requirements for space heating based on details of the individual buildings and the site climate.

6.10 Following the ESAM procedure, Enbuild works at two levels. The Part 1 assessment requires little data about each building, using norms to provide a first estimate of space heating energy requirements. With a similar estimate of the baseload from Enplant, this provides a preliminary assessment of site energy requirement which can be compared to actual consumption to give an indication of potential savings. The Part 2 assessment is much more detailed, requiring data collected from each building on the site.

6.11 The Enbuild program contains the following menu options for entering/amending data:

(i) boilerhouse menu (number, buildings served);

(ii) building menu (number, simple or composite);

(iii) space heating data menu (heated volume, area construction, insulation, glazing, occupancy);

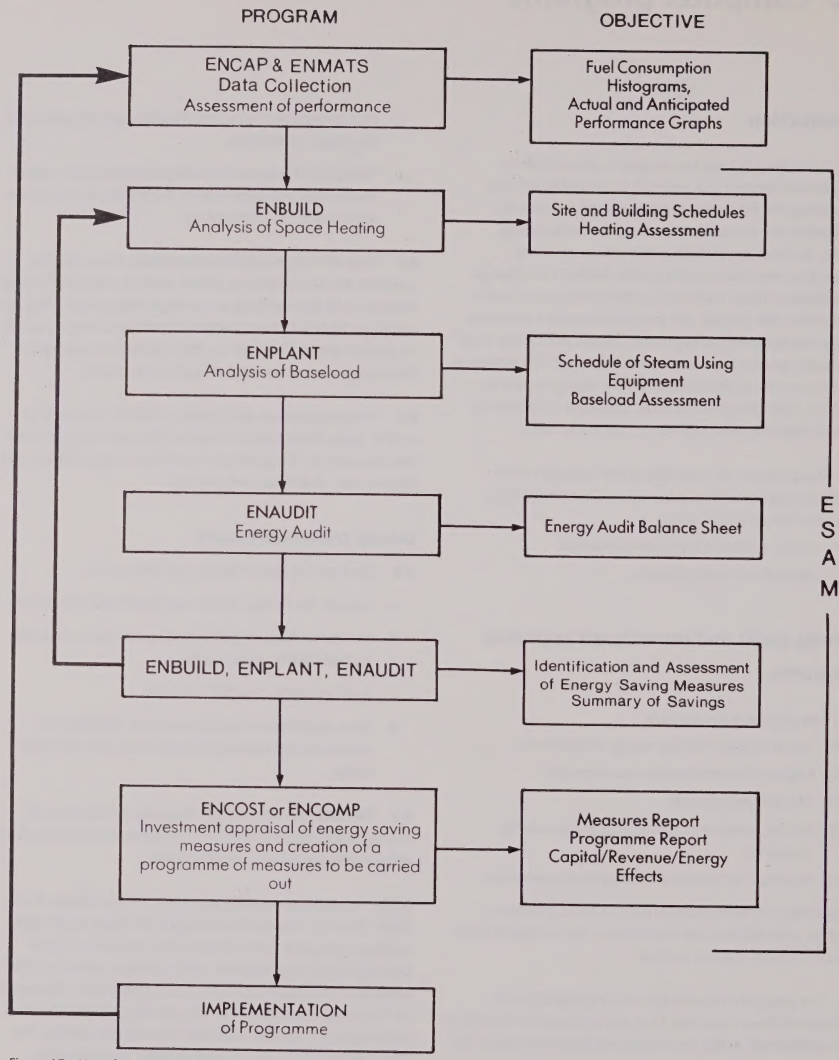

Figure 15 Use of Encode computer programs

(iv) energy-saving proposals menu (good housekeeping, capital improvements).

6.12 Enbuild can also be used as a modelling tool to assess the effect of energy-saving measures, such as fabric or glazing improvements, or the installation of time controls.

6.13 **Enplant** provides facilities to assess the baseload component of the energy provided by the boilerhouses.

6.14 The program identifies the following contributions to the baseload:

a. domestic hot water;

b. steam used by ancillary equipment;

c. steam and hot water for laundries;

d. hot water for swimming/hydrotherapy pools;

e. distribution/circulation losses.

6.15 Enplant will calculate the baseload for each boilerhouse and for the site as a whole.

6.16 The following menu options allow for entering/amending data:

(i) boiler details menu (type, age, monitoring parameters);

(ii) baseload data menu (boilerhouse efficiency, DHW, operating times/steam usage of ancillary equipment, laundry/pool characteristics, distribution/circulation losses).

6.17 **Enaudit** is used to create a balance sheet of actual energy consumption compared with the calculated requirement, the differences providing an indication of potential energy savings. Enaudit combines the annual energy requirements for space heating (calculated by Enbuild) with the baseload requirement (from Enplant), to provide the total energy requirement for each boilerhouse.

6.18 The Enaudit program allows the inclusion of gas and electricity consumption to provide a complete energy audit for all fuels.

Encost and Encomp

6.19 These programs facilitate:

a. investment appraisal;

b. assessment of the costs and benefits of proposed measures;

c. creation of a programme to implement the chosen measures.

6.20 Either program may be used for investment appraisal. Encomp takes a simple approach, working in terms of payback and break-even time. Encost is more sophisticated; it provides facilities to specify future and recurring capital, revenue and energy costs and savings, and takes account of the annual change in fuel costs. It will thus produce a more accurate financial assessment than Encomp, although it requires more detail about each of the proposed measures.

6.21 As the chosen measures are implemented and their effect reflected in lower energy usage, the survey, audit and investment appraisal cycle can be repeated and further energy savings identified.

6.22 **Encost** is based on formulae developed by the Wessex and Oxford regional health authorities. It uses discounted cash flow techniques to calculate the "Net Present Value" (NPV) of the costs and benefits of proposed energy-saving measures and ranks these measures according to the "Benefit Cost Ratio" (BCR), that is, the ratio of the NPV of benefits to the NPV of costs.

6.23 The aim of Encost is to allow a more accurate appraisal of energy-saving measures than is possible using Encomp. It provides facilities to specify future and recurring capital costs, revenue and energy costs and savings, and takes account of changes in fuel costs.

6.24 Each energy-saving measure may affect energy consumption and costs in different ways. For instance, each measure may involve:

- an initial capital cost;
- additional recurring capital costs;
- an increase/decrease in annual maintenance costs;
- annual fuel savings;
- additional annual energy costs.

6.25 In Encost, these "measure items" must be identified separately. The costs or benefits of each are individually discounted back to their NPV and then combined to give a BCR for the entire measure.

6.26 Since certain measures may be dependent on each other, the order in which they are carried out is important. Encost permits the definition of dependencies between measures, indicating when the implementation of one will reduce the energy savings of a subsequent one.

6.27 Once all measures, components and dependencies have been specified, Encost will produce an annual programme of work to be carried out, based on the capital available in each year. Measures are scanned in order of BCR, and added to the programme until the target is reached, taking full account of dependencies.

6.28 **Encomp** is based on the "Energy conservation model related to estate management", developed by the University of Bath. It calculates the payback time of each proposed energy-saving measure, and a "score" that reflects how well

the measure meets the user's requirements. Measures are then ranked according to this score.

6.29 Encomp adopts a simple approach to energy-saving measures, providing alternative methods of calculating the financial viability of each – "simple payback" and "break-even time". The program also allows interdependencies between measures to be defined, but in a less comprehensive manner than Encost.

Data collection and analysis programs

6.30 These programs provide facilities to collect data on fuel and energy use, and to monitor consumption and costs against targets based on past performance.

6.31 Used on a regular basis, they allow a profile of site energy consumption to be compiled over a number of years, and hence support ESAM, in particular site energy performance analysis.

6.32 The programs:

a. are easy to use, with options presented as menus, and all actions clearly prompted;

b. allow any type of fuel, expressed in any units, to be measured and monitored. Values can be converted to GigaJoules for inclusion in overall consumption reports;

c. permit continuous monitoring throughout the year, enabling corrective action to be taken before budgets are exceeded.

6.33 In addition:

a. Enmats provides facilities for regression analysis and allows the baseload and space heating characteristics to be derived from recorded consumption, for comparison with the values calculated by ESAM;

b. Encap helps to ensure that the right meters are identified, and the readings correctly recorded;

c. Encap and Enmats are complementary – the data collected by Encap can be readily loaded into the Enmats database.

Full details of their installation and running are contained in the user manuals.

Encap

6.34 Encap is a utility meter reading system, designed to operate on a handheld Psion Organiser II XP computer. It requires a serial printer for reports and, optionally, a barcode reader.

6.35 To install the system, the details and characteristics of each meter – type (gas, electricity, oil tank with dipstick), measurement units, etc – must be defined. It is strongly recommended that a Psion Organiser Developer is used. This allows the system to be emulated on any PC-compatible micro and means that configuration can be performed using a standard text editor. The Developer is also necessary to transfer data to ENMATS.

6.36 Encap can be used on-site to identify meters, either by entering an identifying code, or by reading a barcode mounted on the meter. Once the meter has been identified, the system prompts the user to input the meter reading, which is then validated within present tolerances. When all the site meters have been read, a report can be produced and the information can be downloaded for permanent storage to a PC, and into another data analysis program such as Enmats.

6.37 Encap is set up so that information about the site meters, the previous year's readings and utility characteristics are contained within ASCII data files.

Enmats

6.38 Enmats is designed to assist engineers and energy managers in monitoring the consumption and cost of fuel, and to provide consumption targets based on past data. It is a replacement for the WIMS Energy Module, offering substantial extra facilities and benefits.

6.39 Enmats defines a hospital site in terms of "blocks" which may be buildings, part of a building, or any other area or item of equipment that needs to be monitored individually. It provides facilities to input and maintain all data related to energy consumption and costs, that is, heated volumes and occupancy, degree day and other weather data, boiler details, meter details, fuel types, tariffs and costs, supply authorities, invoices received, etc.

6.40 Consumption is recorded on a regular basis and the costs calculated from these records, and the corresponding fuel details may be reconciled with costs and consumption itemised on invoices. Enmats offers a wide range of facilities for analysis, reports and graphics production.

6.41 The program is written in the C programming language and will run on any IBM PC-compatible computer that supports the DOS operating system and has at least 640 kb of memory, a hard disk and a single floppy drive.

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7.0 Definitions and reference data

Building measurement definitions

7.1 To ensure consistency in the derivation and reporting of building measurements the information which follows has been taken from:

a. for England and Wales – the Department of Health's "Statement of Central Requirements for Information on Estate Management" (Ref B12 first edition, January 1989);

b. for Northern Ireland – Estate Services Directorate's "Estate Information – The Data Manual" (March 1992).

7.2 These definitions strengthen and consolidate the standard system of measurement contained in:

a. for England and Wales – "Dear Secretary" letter DS232/75 (now superseded by Estmancode Vol 1, Chapter 1, Section 4);

b. for Scotland – "Dear Secretary" letter DS(1976)81 – Estmancode (Scotland);

c. for Northern Ireland – DHSS N Ireland CEL-85-5.

Building area

7.3 Building area should be the overall internal floor area within the perimeter of the external walls.

7.4 This can best be assessed by measuring the building externally, and by deducting from the overall length and width the thickness of the external walls and multiplying the two dimensions.

7.5 Allowances should be made for projections, indentations, insets, voids and courtyards. This area is then multiplied by the number of storeys.

Building volume

7.6 Building volume should be the overall internal volume encompassed by the external walls, the floors and the roof.

7.7 This should be calculated by multiplying the building area, as calculated above, by the storey height. The height of each storey is measured from the floor surface to the underside of the structural floor or roof above, due regard being paid to voids under sloping or pitched roofs.

Heated area

7.8 Heated area should be the overall heated internal floor area.

7.9 The heated area as defined above excludes the area covered by internal walls and partitioning, and such unheated spaces as plant rooms, boilerhouses, ceiling voids, pipe ducts, covered ways, etc (but not laundries). Therefore the heated

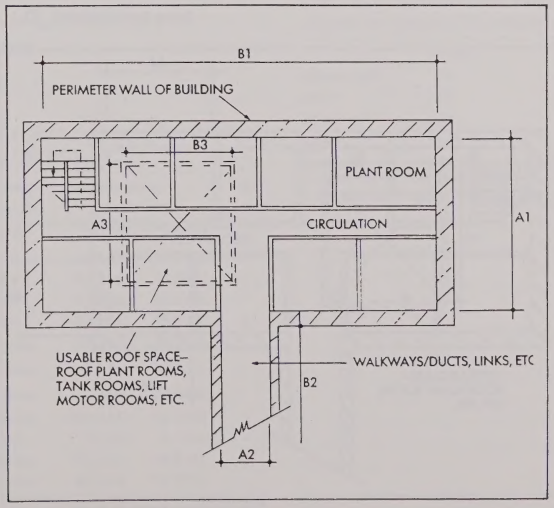

Figure 16 Building area

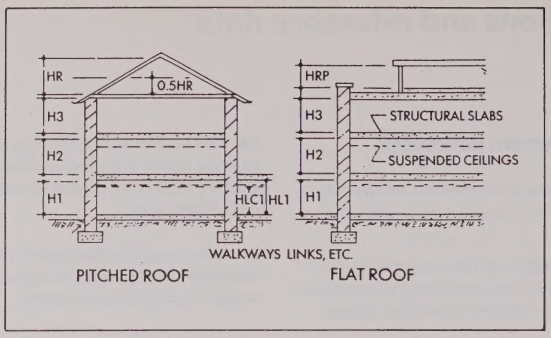

Figure 17 Building volume

area should be calculated by deducting all unheated areas plus the area covered by internal walls and partitioning, from the total building area. Partition areas can be estimated as 6% of the gross area.

7.10 Where floor areas have been calculated on a room-by-room basis, care should be taken to include all heated spaces such as circulation areas, stairwells, etc but to exclude unheated spaces such as plant rooms, ducts, etc.

Heated volume

7.11 Heated volume should be the overall internal heated floor area multiplied by the internal room height.

7.12 This should be calculated by multiplying the heated area, as obtained above, by the distance between the floor surface and the room ceiling.

7.13 While extreme precision is not required in these calculations, all measurements should be as accurate as practicable and rounded off to the nearest 50 mm. This will only be achieved by direct measurement in older hospitals. Where accurate drawings including dimensions exist, the measurements should be based on those dimensions. However, although scaling from drawing is acceptable, a sample test is advisable to confirm the accuracy of this method.

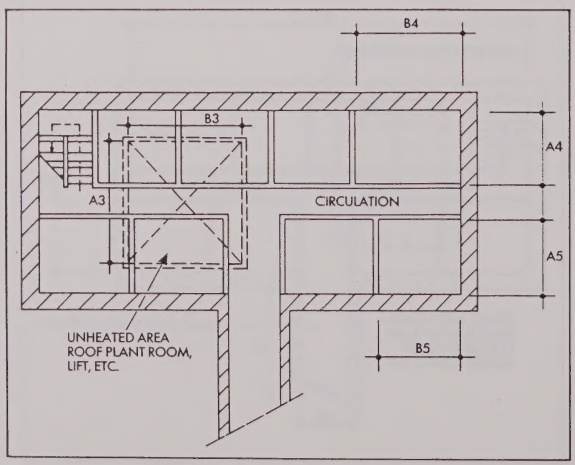

Figure 18 Heated area

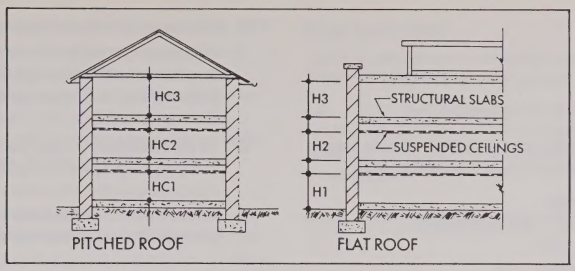

Figure 19 Heated volume

7.14 The above may be quantified in the following equations:

gross floor area = (A1 × B1 × no. of storeys) + (A2 × B2 × no. of storeys) + (A3 × B3)

gross volumes with pitched roof = [A1 × B1 × (H1 + H2 + H3 + 0.5HR)] + [A2 × B2 × (HL1 + HL2 + ...)]

gross volumes with flat roof = [A1 × B1 × (H1 + H2 + H3 ... + 0.5 m)] + [A2 × B2 × (HL1 + HL2 + ...)] + (A3 × B3 × HRP)

Note: 0.5 m represents a notional compensating height to allow for a flat roof.

heated volumes = [A1 × B1 × (HC1 + HC2 + ...) × 0.94] + [A2 × B2 × (HLC1 + HLC2 ...)] – (A4 × B4 × HC1)

Note: 0.94 represents the 6% reduction in overall floor area to allow for the internal walls and partitions.

Calorific values, CO_2 emissions and conversion factors

Calorific values

7.15 Table 2 shows the calorific values of different fuels:

Table 2 Calorific value per unit of supply

Fuel	Unit of supply	Calorific value gross	net	BS class
Electricity direct	kWh	3.6 MJ	3.6 MJ	–
Fuel oil: 35 secs	litre	38.1 MJ	35.7 MJ	D
200 secs	litre	40.4 MJ	38.2 MJ	E
950 secs	litre	40.6 MJ	38.4 MJ	F
3500 secs	litre	41.1 MJ	38.8 MJ	G
Coal singles	tonne	28.4 GJ	27.2 GJ	–
Coal smalls	tonne	28.1 GJ	26.9 GJ	–
Coke	tonne	27.9 GJ	27.4 GJ	–
Gas: natural	Therm	105.5 MJ	92.5 MJ	–
"	kWh	3.6 MJ	3.16 MJ	–
propane	tonne	50.0 GJ	46.3 GJ	–
butane	tonne	49.3 GJ	45.8 GJ	–

Note: The calorific value of all fuels should always be confirmed with the supplier, especially that for heavy fuel oil.

Table 3 Carbon dioxide emissions – fossil fuels

	CO_2 Carbon kg/tonne	CO_2 Carbon kg/GJ	CO_2 kg/GJ	Delivered CO_2 kg/GJ
Coal power station	588.2	19.2	70.4	74.6
Coal domestic	676.6	22.3	83.6	88.6
HFO	850	20.2	74.1	80.0
Gas oil	857	18.9	69.3	74.8
Derv	857	18.9	69.3	74.8
Petrol	855	18.5	67.8	73.2
Natural gas	1 537 000*	14.6	53.5	57.8

* kg/MTh

Calorific values: coal (steam) 30.6 MJ/kg
anthracite 29.7 MJ/kg
gas oil 45.3 MJ/kg
derv 45.3 MJ/kg
petrol 45.9 MJ/kg
natural gas 53.4 MJ/kg

7.16 An energy reduction of 1000 GJ at the point of use can yield the following CO_2 reduction for various fuels:

	Tonnes
Natural gas*	77
HFO*	107
35 sec oil*	100
Coal*	118
Electricity	248 (at a coal burning power station)

* Assumes boilerhouse efficiency of 75%.

Conversion factors

7.17 Table 4 provides some useful conversion factors. They are presented in three-column form, for example:

3.280 84 feet 1 0.304 8 metres

with the unit in the middle column serving for feet or metres. This is a convenient "one-line" way of expressing that:

3.280 84 feet = 1 metre
1 foot = 0.304 8 metres

Table 4 Conversion factors

	Imperial		SI
Length	3.280 84 ft	1	0.304 8 m
	1.093 613 yd	1	0.914 4 m
	0.621 371 miles	1	1.609 34 km
Area	10.764 ft^2	1	0.092 9 m^2
Volume	35.314 7 ft^3	1	0.028 317 m^3
Capacity	0.219 975 Imp gal	1	4.545 963 litre
Mass	2.204 622 62 lb	1	0.453 592 37 kg
	0.984 206 tons	1	1.016 051 (tonnes)
Power	1.341 02 bhp	1	0.745 70 kW
Energy	0.277 778 kWh	1	3.6 MJ
	0.947 813 Btu	1	1.055 06 kJ
	9.478 134 Therm	1	0.105 506 GJ
Calorific value	0.429 92 Btu/lb	1	2.326 kJ/kg
	0.238 85 kcal/kg	1	4.186 8 kJ/kg
	0.026 839 Btu/ft^3	1	37.258 9 kJ/m^3
	4.308 86 Btu/gal	1	0.232 08 MJ/m^3
Heat flow	3.412 Btu/h	1	0.293 071 W
	3.412 lb steam/h	1	0.293 1 kW (approx)

Other useful conversion factors are:

1 GigaJoule (GJ)		= 10^9 Joules
		= 948 000 Btu
		= 9.48 Therms
		= 277.78 kWh
		= 976.71 lb steam/h
1 Therm	× 0.1055	= GigaJoules
1 000 000 Btu	× 1.055	= GigaJoules
1 kWh	× 0.0036	= GigaJoules
1,000 lb steam	× 1.024	= GigaJoules

Boilerhouse efficiency factors

7.18 Realistic values for the assessed annual efficiency of the boilerhouse (that is, the annual net heat exported from the boilerhouse divided by the heat supplied) are required for ESAM site energy performance analysis and assessment of site energy requirement. Assessments of potential annual efficiency are required in the assessment of potential savings.

7.19 Boilerhouse efficiency is dependent on several factors:

(i) those relating to the boilers themselves include type, condition, cleanliness, combustion efficiency, stoking performance, water treatment, blow down and heat exchange efficiency;

(ii) for the boilerhouse in total, the factors are mainly concerned with operational policies including consumption within the boilerhouse or part of the boiler output, the use of reserve hot boilers, the control of load factor and individual boiler loads.

7.20 Efficiency assessments can be made by:

(i) direct calculation from log sheets where these include reliable meter readings of boilerhouse output over a whole year;

(ii) adjustment of "spot" measured efficiency of the boilers alone, to allow for the factors mentioned above over the whole year;

(iii) estimation, using the average overall boilerhouse efficiencies given in Table 5 for hospitals as default values.

Table 5 Boilerhouse efficiencies

	Average overall efficiency (%)*		
Boiler type	Coal	Gas	Oil
Steam, Economic	57–77	67–80	67–82
Lancashire	53–61	61–70	61–71
Super Lancashire	55–65	65–74	65–75
Vertical Gross Tube	64–72	67–71	67–72
Package	60–80	70–83	70–85
HPHW/MPHW	Approx as for package steam boilers		
	←		→
LPHW	50–65	70–75	65–70
Condensing	–	85–92	–
Modular	–	80–85	80–85
CHP	–	80–86	–

* Ranges for 2–4 boilers giving 20 to 50 × 10^6 kg of steam per annum

7.21 The following points quantify and describe the corrections which need to be made to actual boiler spot efficiencies from paragraph 7.20(ii) to obtain the assessed annual efficiency. They can also be used in applying the average efficiency ranges given in Table 5 to specific boilerhouses:

a. number and loading of boilers in use. The difference in efficiency between best and worst conditions can be up to 15%;

b. fuel heating in storage tanks and pipelines, where this is done by steam or hot water from the boilerhouse. This will vary with fuel usage rate, an average heat consumption being about 1% of average boilerhouse output, where heavy fuel oil (HFO) is used and two weeks' storage is held, assuming reasonable insulation of tanks and pipes. Economy may be possible; see 'Encode 2';

c. fuel injection or atomisation by steam. This varies with burning rate and is about 4% of boiler output on HFO. This constitutes a serious loss of treated water as well as of steam output. Replacement of steam injection by pressure jet or air injection may be considered, but a reduction in reliability and an increase in flue losses has sometimes resulted from such action;

d. feed pumps – steam driven. Feed pump steam input varies with boiler output and is about 1.5–4% of boilerhouse output according to the type and condition of the pump. The exhaust steam is normally used for feed water heating to give considerable savings in running costs. It is still deducted from the boiler or boilerhouse output in calculating overall efficiency, as the saving is accounted for by the reduced fuel input;

e. circulating pumps (LPHW and DHWS) and vacuum ejectors using sub-atmospheric steam. No correction is needed;

f. draught assistance – steam operated. Unusual except on older coal-fired boilers, but where steam jets are used the consumption varies between 5% and about 15% of the boiler plant output, according to design. There may be scope for reducing the steam rate;

g. blow down. The loss should be proportional to the evaporation rate and for boilers operating at about 7 bar would represent about 0.3% of the fuel input rate for each 1% of water feed rate blown down. Loss of heat (and valuable treated water) to drains should obviously be minimised and consideration given to heat recovery from continuous automatic blow down;

h. reserve – hot boiler standby. The heat lost by this practice is fairly uniform for a given boiler and can be 2–10% of the maximum fuel consumption, depending on type of boiler and whether flue dampers are provided.

Base load data

Steam consumption

7.22 Table 6 quantifies steam consumption for plant and individual items of equipment; the data is typical of hospital usage, but the figures may be varied to suit individual circumstances.

Table 6 Steam consumption – equipment and plant

	kg/h	Hours per day	Days per month	Cycle diversity
Boiling pan 23 litres	13	5	30	0.5
45 litres	17	5	30	0.5
68 litres	27	4	30	0.5
91 litres	32	4	30	0.5
Hot cupboard	7	12	30	0.7
Bain-marie servery counter	7	8	30	0.7
Hotplate	5	12	30	0.8
Tea boiler	7	8	30	0.8
Still boiler cafe set	7	8	30	0.8
Steaming oven 0.04 m^3	7	4	30	0.5
0.06 m^3	11	4	30	0.5
0.11 m^3	27	4	30	0.5
0.17 m^3	59	4	30	0.5
0.34 m^3	91	4	30	0.5
Rotopan	9	4	30	1.0
Dishwasher	14	6	30	0.8
Bottle washer	9	4	30	1.0
Still 36 litres/h	45	6	24	1.0
68 litres/h	82	6	24	1.0
Steriliser 0.085 m^3	7	5	24	1.0
0.14 m^3	14	5	24	1.0
0.17 m^3	16	3	24	0.5
Milk	5	4	30	1.0
Crockery	9	2	30	0.5
Instrument	5	2	24	1.0
Bowl/instrument (TSSU)	5	2	24	1.0
Bedpan	11	2	30	1.0
Autoclave 0.28 m^3	27	5	24	0.5
0.59 m^3	41	5	24	0.5
Theatre air-conditioning	27	24	30	1.0
Steam re-heat, per theatre	23	24	30	1.0

Laundry consumption

7.23 Table 7 provides a guide to the consumption of steam, water and electricity in laundries of varying capacity. However, estimates of consumption must relate to the type of equipment selected to suit the particular laundry load. Laundries dealing with large volumes of flatwork, for example, will be less energy demanding than those with high volumes of more general work.

7.24 Differences in steam, water and electricity consumption between the batch continuous tunnel washing system and the washer extractor system are given where appropriate.

Table 7 Laundry consumption

Articles weekly (pieces)	55,000	100,000	150,000	200,000
Dry weight (kg) @ 0.432 kg ± 0.02 kg	23,760	43,200	64,800	86,400
Steam – approx hourly consumption				
Tunnel washer installation	kg	kg	kg	kg
High pressure	1,500	2,800	3,900	5,200
Low pressure	435	770	1,100	1,500
Alternative W/E installation				
High pressure	1,500	2,800	–	–
Low pressure	615	1,100	–	–
Water – approx hourly consumption				
Tunnel washer installation	litres	litres	litres	litres
Cold 65%	6,800	12,400	18,500	24,200
Hot 35%	1,200	2,200	3,300	3,500
Alternative W/E installation				
Cold	8,900	16,200	–	–
Hot	4,800	8,700	–	–
Electricity – units per hour				
Tunnel washer installation (approx 100–110 units per 100 kg dry weight)	kWh 67	kWh 122	kWh 166	kWh 221
Alternative W/E installation (approx 120 units per 100 kg dry weight)	73	133	199	266

Steam and water losses

7.25 Table 8 shows typical monthly steam and hot water losses as a percentage of site consumption.

Table 8 Distribution steam and hot water mains losses

Hospital plant and layout	%
Integral LPHW plant in small hospitals	4–6
Steam or HPHW distribution to local calorifiers	6–10
Site with steam, LPHW and DHWS	10–15

Heat loss data

Building heat loss

7.26 The data in Table 9 shows the variation in building heat loss according to the type of construction.

Table 9 Typical building heat loss values at design conditions (W/m^3)

Construction	High ceiling glazing 20%	40%	Low ceiling glazing 20%	40%
Traditional heavy or cavity brick pitched roof – no insulation	31	36	26	29
As above plus 75 mm roof insulation	25	29	20	22
Typical 1960/70 fabric – concrete frame – infill panels – flat roof	22	27	19	22
Modern to current Building Regs – multi leaf – heavy insulation	17	22	15	18
Vic Hallam/prefabricated wooden frame and panels – flat roof	21	25	18	21
Light single leaf brick – plaster – pitched roof – no insulation	35	42	27	31

U values

7.27 Tables 10, 11 and 12 quantify U values for walls, roofs and floors. In each, the data is based on normal exposure conditions and adjustments must be made as necessary.

Table 10 U values for walls

Construction	U values (W/m^2 °C)
105 mm brick – 13 mm plaster	3.0
105 mm brick – 50 mm battens G/F – plasterboard	0.82
105 mm brick – 50 mm air gap – 105 mm brick – 13 mm plaster	1.5
105 mm brick – 50 mm (UF) foam – 105 mm brick – 13 mm plaster	0.45
105 mm brick – 50 mm air gap – 105 mm block – 13 mm plaster	0.96
105 mm brick – 50 mm (YF) foam – 105 mm block – 13 mm plaster	0.41
105 mm brick – air gap – 220 mm brick – plaster	1.31
105 mm brick – 50 mm (UF) foam – 220 mm brick – plaster	0.50
105 mm brick – 65 mm (UF) foam – 220 mm brick – plaster	0.40
105 mm brick – 75 mm (UF) foam – 220 mm brick – plaster	0.35
105 mm brick – air gap – 335 mm brick – plaster	1.09
105 mm brick – 50 mm (UF) foam – 335 mm brick – plaster	0.44
105 mm brick – 65 mm (UF) foam – 335 mm brick – plaster	0.37
105 mm brick – 75 mm (UF) foam – 335 mm brick – plaster	0.33
220 mm brick – 13 mm plaster	2.1
220 mm brick – 50 mm battens G/F – plasterboard	0.53
335 mm brick – 13 mm plaster	1.84
335 mm brick – 50 mm battens G/F – plasterboard	0.53
335 mm brick – plastered	1.64
440 mm brick – plastered	1.37
Asbestos sheet – 50 mm battens – fibreboard	1.84
Asbestos sheet – 50 mm battens G/F – fibreboard	0.51
Vic Hallam type 20 mm board – 25 mm plasterboard	0.79
100 mm concrete – 30 mm polystyrene – 100 mm concrete – plasterboard	0.81

Table 11 U values for roofs

Construction	U values (W/m^2 °C)
Pitched roofs	
Pitched roof – tiles on battens – plaster	3.15
As above plus 25 x glassfibre	0.79
As above plus 75 mm total glassfibre	0.37
As above plus 100 mm total glassfibre	0.34
Pitched roof – asbestos sheet – roof space	1.9
As above plus 75 mm total glassfibre	0.38
As above plus 100 mm total glassfibre	0.32
Pitched roof – felt on timber – roof space – plaster ceiling	1.4
As above plus 75 mm total glassfibre	0.35
As above plus 100 mm total glassfibre	0.31
As above plus 150 mm total glassfibre	0.24
Pitched roof – tiled on boards – felt – plaster ceiling	1.64
As above plus 150 mm glassfibre	0.23
Pitched roof – slate – plaster ceiling	2.55
As above plus 150 mm glassfibre	0.23
Flat roofs	
Flat roof Vic Hallam type – chippings on felt – 9.5 mm ply – roof space – 25 mm glassfibre – plasterboard	0.95
Flat roof asphalt – 150 mm woodwool – 25 mm G/F – ceiling tiles	0.61
Flat roof asphalt – 150 mm aerated concrete – plaster ceiling	0.84
As above plus 50 mm expanded polystyrene	0.37

Table 12 U values and heat losses for floors

Construction	U value (W/m^2 °C)	Annual loss ($GJ/annum\ m^2$) Degree days Hospital	Standard
Solid floor	0.30	0.089	0.064
Suspended wood floor	0.40	0.119	0.085
Suspended wood floor 25 mm fibreglass below	0.31	0.092	0.066
Suspended wood floor 50 mm fibreglass below	0.28	0.083	0.059

Formula used:

$$\text{Annual heat loss} = \frac{DD \times U\ \text{value} \times 24 \times 3600}{10^9}\ GJ/annum\ m^2$$

where DD = 3448 hospital degree days
= 2462 standard degree days
or 20-year average for the degree day area.

Ventilation heat loss

7.28 Table 13 quantifies heat losses from ventilation where heating is continuous.

Table 13 Ventilation heat losses

Air changes (per hour)	Annual loss GJ/annum m^3 Degree days Hospital	Standard
0.5	0.025	0.017
1.0	0.049	0.035
1.5	0.073	0.052
2.0	0.098	0.070
2.5	0.123	0.087
3.0	0.148	0.145
3.5	0.172	0.122
4.0	0.197	1.140
4.5	0.221	0.157
5.0	0.246	0.175

Formula used:
Annual heat loss

$$= \frac{DD \times \text{ventilation allowance} \times 24 \times 3600}{10^9} \times \frac{1}{2}^{*} \text{ GJ/annum m}^3$$

where DD = 3448 hospital degree days
= 2462 standard degree days
or 20-year average for the degree day area

and ventilation allowance = 0.33 × air change rate as defined in CIBSE guide A4.

* The values in Table A4.8 of the CIBSE Guide are the rates applicable to single rooms. Thus the load on the central plant due to the ventilation heat loss will be about half the total of those for individual rooms, save in certain obvious special cases, where all rooms have at least two opposite external walls with windows and doors. Hence the factor of $\frac{1}{2}$ in the above equation.

Intermittent heating factors

7.29 Table 14 quantifies intermittent heating factors according to the building's construction and plant response rate.

Table 14 Intermittent heating factors

Construction	Plant response rate	7 days/week Con-tinuous	16 hrs	12 hrs	8 hrs	5 days/week Con-tinuous	16 hrs	12 hrs	8 hrs
Heavy									
Buildings of curtain walling	fast	1.00	0.88	0.87	0.85	0.85	0.74	0.74	0.72
masonry or concrete,	medium	1.00	0.90	0.89	0.87	0.85	0.76	0.75	0.74
especially multi-storey.	slow	1.00	0.93	0.92	0.90	0.85	0.79	0.78	0.77
Large glass area, solid floors									
Medium									
Single storey buildings of	fast	1.00	0.85	0.79	0.70	0.80	0.68	0.63	0.56
masonry or concrete with	medium	1.00	0.92	0.87	0.77	0.80	0.74	0.70	0.62
solid partitions. Curtain	slow	1.00	1.00	0.96	0.85	0.80	0.80	0.77	0.68
walling, areas of solid partition									
Light									
Single storey of factory type.	fast	1.00	0.77	0.69	0.55	0.70	0.54	0.48	0.39
Top floor of multi-storey	medium	1.00	0.87	0.78	0.62	0.70	0.63	0.54	0.44
buildings without partitions	slow	1.00	0.98	0.88	0.70	0.70	0.69	0.61	0.49

Plant response – fast direct electric or gas fired air heaters;
medium hot water radiators, natural draught convectors, ceiling panels;
slow embedded panels.

Structure heat loss

Hospital degree days

7.30 Figures 20 and 21 show how the annual heat loss through the building structure varies with the proportion of glazing – both single and double. Each graph assumes 3448 hospital degree days and continuous heating.

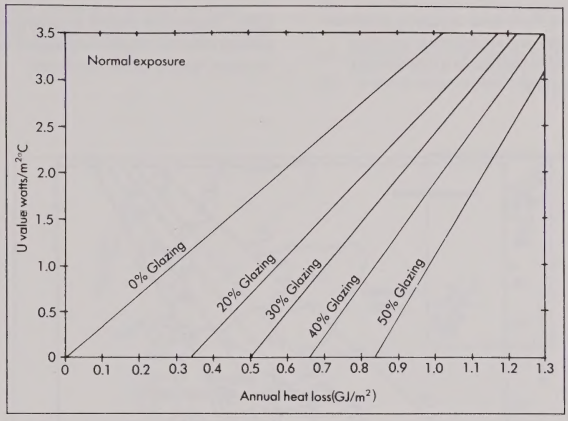

Figure 20 Single glazing – hospital degree days

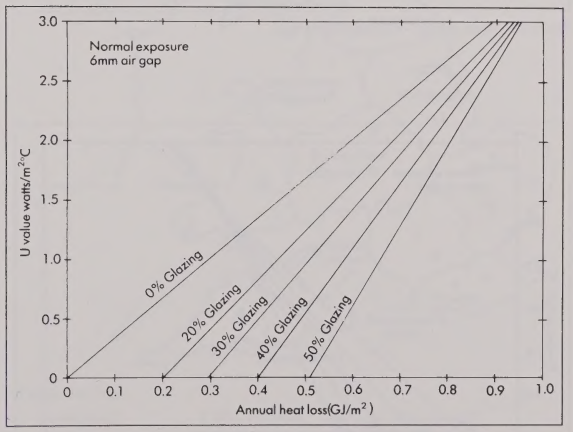

Figure 21 Double glazing – hospital degree days

7.31 Formulae used:

$$\text{Annual heat loss} = \frac{\text{DD} \times \text{overall U value} \times 24 \times 3600}{10^9}$$

$$\text{Overall U value} = \left(\frac{G}{100} \times Ug\right) + \left(\frac{100-G}{100} \times Uf\right)$$

where G = % glazing;
Ug = 5.6 for single glazing;
Ug = 3.4 for double glazing;
Uf = U value of wall or roof fabric.

7.32 To use – determine the U value of wall (or roof) from heat loss data (or calculate), and read off heat loss from appropriate glazing curve. In the case of a roof without skylights, use 0% glazing line.

Standard degree days

7.33 Figures 22 and 23 also show structure heat loss but assume 2462 standard degree days and continuous heating.

7.34 The formulae and method of use are the same as for figures 20 and 21.

Degree days

7.35 Degree days provide a convenient measure of the average external temperature, against which the energy used for space heating can be monitored.

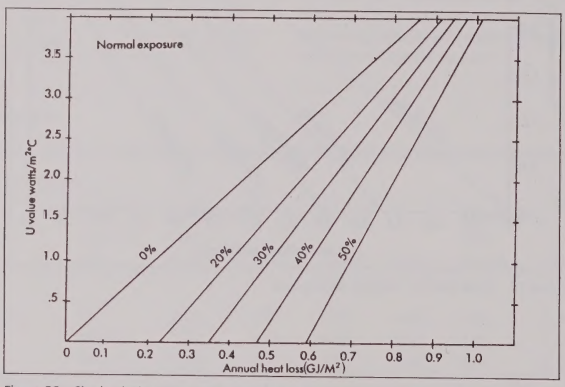

Figure 22 Single glazing – standard degree days

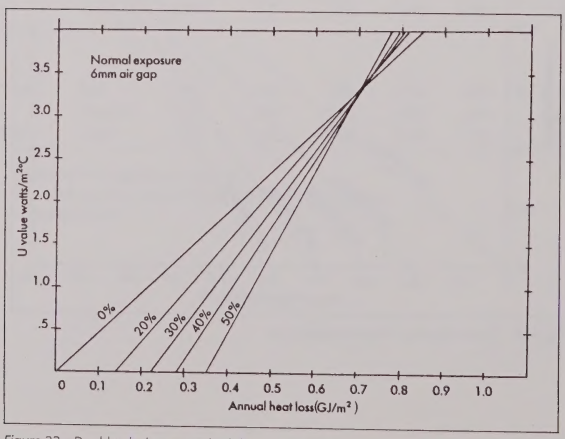

Figure 23 Double glazing – standard degree days

7.36 Degree days to a base temperature of 15.5°C are related to an internal temperature of 18.3°C and are applicable to most offices, industrial premises, etc. However, the average internal design temperature for hospitals is about 20°C while the comparatively low density of occupation, plus the limited amount of machinery, probably result in incidental gains of less than 2.8°C. As a result, the correlation with degree days to base 15.5°C is poor. Thus, a specially computed table of degree days to a base temperature of 18.5°C is more appropriate to most hospital usage. The base of 15.5°C should, however, continue to be used for those buildings with an average internal design temperature around 18.3°C.

Source data

7.37 Sample degree day sheets are included at the end of this chapter. In addition, hospital and standard degree days are issued monthly by the Estates Directorate of the Department of Health and are published on the EIC Bulletin Board and in the HSE Journal.

7.38 For each of the 17 Meteorological Office regions in the UK (Figure 24), they show:

(i) monthly and annual average degree days for a 20-year period;

(ii) monthly and total degree days for the previous year;

(iii) monthly degree days to date for the current year.

Degree day areas

1 Thames Valley
2 South Eastern
3 Southern
4 South Western
5 Severn Valley
6 Midland
7 West Pennines
8 North Western
9 Borders
10 North Eastern
11 East Pennines
12 East Anglia
13 West Scotland
14 East Scotland
15 North East Scotland
16 Wales
17 Northern Ireland

Figure 24 Meteorological office degree day areas

7.39 Either type of degree day figure may be used for monitoring but as they are not interchangeable, each exercise must consistently use degree day figures to the same base. Similarly, if a site is subdivided for monitoring against different degree day figures, consistency is again essential.

Basis of degree days

7.40 In broad terms, the amount of energy required to heat a given space is related to:

(i) the temperature difference between the heated space and its surroundings;

(ii) the period of time for which heating is required.

7.41 Figure 25 shows these relationships graphically; the energy needed is represented by the shaded area, below the required temperature and limited by the external temperature. If time is measured in days, and the temperature difference in degrees, then the energy requirement is assessed in degree days.

7.42 Degree days may be measured to any required base temperature and aggregated over any desired period – month by month, over the heating season, or annually.

7.43 The higher base temperature results in an increase in the number of degree days, not only because the temperature difference (internal to external) is greater, but also because the heating period is extended; see Figure 26. It is possible to estimate the difference in degree days between two base temperatures, but this involves some approximation and error.

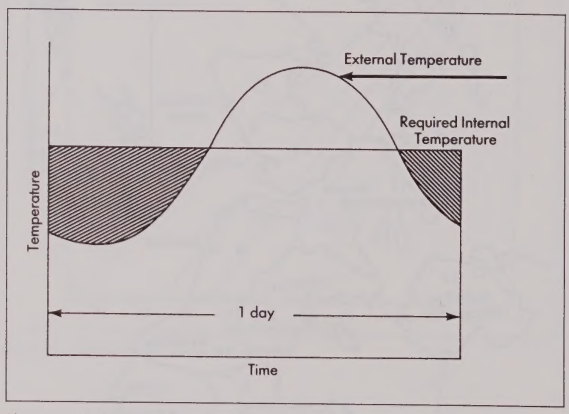

Figure 25 The basis for degree days

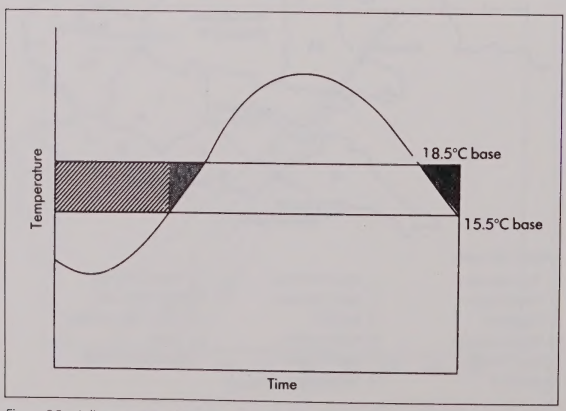

Figure 26 Adjustment for different base temperatures

Application of degree days

7.44 If the total degree days for one period are twice that of the previous period, the space heating energy requirement will be doubled. However, degree days alone will not put a value on that requirement. The implication is that the ratio of energy requirement to degree days should be substantially constant. If energy for space heating usage is plotted against degree days month by month (Figure 27), the points should lie very close to a straight line through the origin; any substantial variation should be investigated and analysed. The straight line can sometimes be determined by eye but regression analysis, as outlined in Chapter 7, results in a more accurate fit.

7.45 However, a typical hospital boilerhouse supplies many other loads in addition to space heating, for example:

- domestic hot water;
- laundry process steam;
- laundry hot water;
- catering equipment;
- sterilising plant;
- air-conditioning plant air heaters;
- distribution and circulation losses.

These loads may represent more than half the annual boilerhouse output. The graph can now be redrawn to show this as in Figure 28.

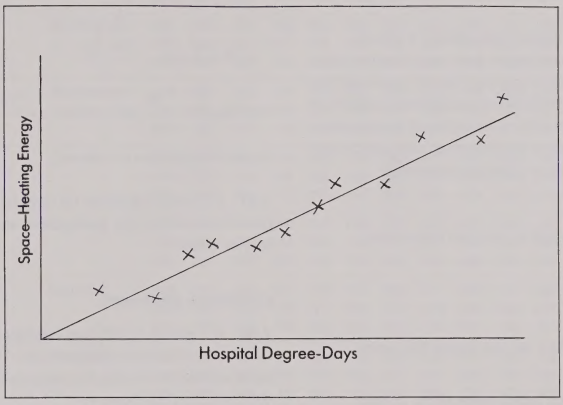

Figure 27 Space heating energy v. degree days

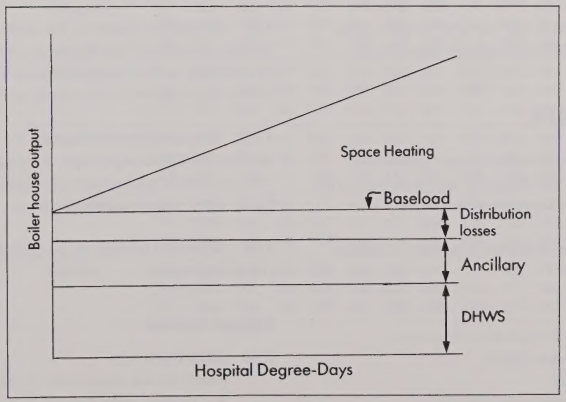

Figure 28 Boilerhouse output v. degree days

Intermittent heating

7.46 Intermittent heating may be long-term, for example summer shutdown, or short-term, five-day week with night setback.

7.47 Summer shutdown can be covered by adjustments to the degree day figures:

(i) July/August – if heating is shut down during this period it is reasonable to ignore the degree days for these months when considering the output/degree day line;

(ii) June and September – since heating is generally required for around half of each month, these periods may well account for up to two-thirds of the degree days for the respective whole months. It is reasonable, therefore, to include energy consumption in these months in the analysis.

7.48 A five-day week and/or night setback is a more difficult problem. Accurate degree days would require special temperature readings for the periods involved, and even then, the thermal capacity of the buildings would have a significant effect on energy requirements. Comparison of degree days over short periods is likely to be misleading; comparison over the entire heating season, or a year, is much more meaningful.

7.49 Table 14 can be used to adjust for intermittent heating.

Degree day tables

7.50 Tables 15 and 16 are sample degree day sheets. On each:

a. the first row in each month refers to the 20-year average (April 1968 to March 1988);

b. the second row provides values for the year April 1988 to March 1989;

c. the third row refers to the "current" period – in this case from April 1989 to the sheets' date of issue.

Regression analysis

7.51 A full description of this technique is given in HSE 33–35 (see paragraph 7.60 below) but for the purpose of this manual, the calculations are summarised below.

7.52 The graph we are concerned with, being a straight line, follows the equation:

$y = mx + c$

where y = monthly fuel consumption (GJ/month);
m = constant slope (GJ/DD);
x = degree days;
c = constant base load (GJ/month).

7.53 The constants m and c have to be evaluated to give the best fit. The first step is to tabulate x, y, xy, x^2 and y^2 and then to total the columns:

n	x	y	xy	x^2	y^2
1	.	.			
2	.	.			
.	.	.			
.	.	.			
n	.	.			
Σ	x	y	xy	x^2	y^2

7.54 These totals are then used to calculate intermediate values:

$$K = \Sigma(x^2) - \frac{(\Sigma x)^2}{n}$$

$$L = \Sigma(y^2) - \frac{(\Sigma y)^2}{n}$$

$$M = \Sigma(xy) - \frac{(\Sigma x\ \Sigma y)}{n}$$

then slope $m = \frac{M}{K}$ and constant $c = \frac{\Sigma y - m\Sigma x}{n}$

to give the equation $y = mx + c$

7.55 If y is then calculated for low and high values of x, this gives two points on the graph, between which a straight line may be drawn.

Correlation coefficient

7.56 K, L and M are arbitrary constants used in the calculation of the intermediate values. These calculations are recommended to simplify the computation of m and c and the correlation coefficient r:

$$r = \frac{M}{\sqrt{K \times L}}$$

7.57 As noted in Chapter 2, the correlation coefficient is a numeric indication of the degree of scatter. It is 1.0 or unity if all points are on the line, zero if the points are wholly random, while a figure above 0.9 is generally satisfactory.

7.58 The point where the line cuts the fuel consumption axis, that is, at zero degree days, is a measure of the base load, and should approximate the July/August consumption figure, when space heating is minimal.

7.59 Regression analysis can be carried out using Enmats computer program.

Support material

7.60 CIBSE Guide A3;
Health Service Estate (HSE) 33, 34 (out of print);
35 "Hospital degree days," Sept 1977, DHSS.

Table 15 Hospital degree day

18.5°C

AREA	STATION	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1 THAMES VALLEY	Heathrow	292	200	110	63	68	116	215	331	405	436	403	379	3018
		276	161	107	89	74	122	203	378	337	376	338	304	2765
		318	123	99	35	54	77	160	337	364	348	283	290	2488
2 SOUTH EAST	Gatwick	321	234	139	89	97	151	247	356	427	458	425	404	3348
		306	187	130	106	98	142	219	394	351	401	355	327	3016
		342	167	130	51	76	102	191	370	388	374	294	324	2809
3 SOUTHERN	Bournemouth	316	233	138	91	96	147	237	341	405	436	408	393	3241
		313	194	128	108	110	144	218	383	345	378	347	325	2993
		354	175	138	64	91	123	196	340	394	347	284	330	2836
4 SOUTH WESTERN	Plymouth	295	226	136	85	85	128	205	296	351	384	366	363	2920
		286	192	105	120	110	132	192	311	282	333	303	304	2670
		332	142	112	34	62	99	165	274	332	311	361	292	2416
5 SEVERN VALLEY	Bristol	299	218	123	73	80	130	226	326	394	428	400	386	3083
		271	169	96	104	88	119	201	342	298	341	310	300	2639
		320	125	101	27	50	88	174	313	373	326	274	285	2456
6 MIDLAND	Birmingham	331	248	153	99	108	163	263	365	436	467	439	415	3487
		333	218	141	121	118	165	263	422	344	394	361	349	3229
		367	188	147	68	90	133	222	385	428	379	311	308	3026
7 WEST PENNINES	Manchester	318	229	145	97	99	153	246	357	421	453	421	405	3344
		300	204	124	124	121	176	254	398	352	378	353	355	3139
		366	188	144	67	100	136	219	363	444	374	317	321	3039
8 NORTH WESTERN	Carlisle	333	254	164	116	122	176	262	372	431	466	425	416	3537
		319	232	129	138	126	188	257	396	350	365	350	378	3228
		381	197	164	77	101	155	209	379	504	369	335	337	3208
9 BORDERS	Boulmer	360	297	198	140	142	185	273	372	432	468	430	424	3721
		348	282	179	142	135	178	270	376	339	364	366	383	3362
		381	255	197	107	116	169	233	350	436	397	341	316	3298
10 NORTH EASTERN	Leeming	335	255	159	105	112	163	265	371	439	474	438	416	3532
		312	328	132	119	111	163	264	412	342	381	355	357	3186
		370	199	149	68	94	142	220	370	451	382	319	309	3073
11 EAST PENNINES	Finningley	320	238	146	96	100	152	253	362	434	465	432	408	3406
		316	229	136	114	103	165	257	407	350	384	356	344	3161
		369	197	148	72	89	117	214	379	432	385	318	309	3029
12 EAST ANGLIA	Marham	327	233	140	93	92	139	241	359	434	468	434	410	3370
		314	201	147	115	99	147	236	414	383	408	364	337	3165
		366	186	146	61	76	100	193	372	416	373	306	314	2909
13 WEST SCOTLAND	Glasgow	335	258	169	126	133	193	279	389	445	476	432	422	3657
		325	245	126	141	137	190	290	398	343	350	374	400	3319
		370	237	176	97	130	198	244	399	514	393	344	336	3438
14 EAST SCOTLAND	Leuchars	352	288	187	131	138	191	282	391	447	481	438	426	3752
		338	273	159	142	130	180	292	395	365	369	378	393	3414
		371	231	180	102	121	190	247	374	494	414	358	327	3409
15 N E SCOTLAND	Aberdeen	366	296	200	147	152	210	294	401	455	493	449	440	3903
		351	274	168	146	150	193	296	381	364	369	382	398	3472
		391	255	193	111	143	193	274	372	484	425	368	338	3547
16 WALES	Aberporth	329	260	173	122	117	157	236	325	387	422	402	399	3329
		311	239	150	159	142	171	235	346	316	365	345	354	3133
		362	208	163	86	100	145	210	320	409	359	316	328	3006
17 N IRELAND	Belfast	332	260	168	121	128	180	264	372	422	458	415	413	3533
		297	235	137	142	144	189	265	379	350	371	368	377	3254
		372	228	156	82	122	183	238	366	446	399	367	327	3286

Table 16 Standard degree day

15.5°C

AREA	STATION	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1 THAMES VALLEY	Heathrow	205	120	51	22	24	54	130	242	312	343	318	286	2107
		189	86	48	31	27	56	116	288	244	283	254	215	1837
		228	63	51	11	21	30	78	247	271	255	199	200	1654
2 SOUTH EAST	Gatwick	233	150	73	39	44	82	160	267	334	365	340	311	2398
		217	108	62	43	43	72	132	304	258	308	271	237	2055
		252	99	74	21	36	45	106	280	295	281	210	233	1932
3 SOUTHERN	Bournemouth	229	148	72	39	42	79	150	251	312	343	323	300	2288
		224	113	63	41	49	75	131	293	252	285	263	233	2022
		264	105	81	29	44	62	111	251	301	254	200	238	1940
4 SOUTH WESTERN	Plymouth	207	137	63	29	28	55	116	206	258	291	281	270	1941
		196	107	43	35	35	56	101	221	189	240	219	211	1653
		242	74	53	7	18	36	76	184	239	218	177	200	1524
5 SEVERN VALLEY	Bristol	211	133	59	25	29	61	138	236	300	335	315	293	2135
		182	89	40	33	27	47	111	252	205	248	226	209	1669
		230	62	48	5	14	30	87	224	280	233	190	194	1597
6 MIDLAND	Birmingham	243	162	83	44	48	90	173	275	343	374	354	322	2511
		244	134	72	52	54	88	172	332	251	301	277	257	2234
		277	115	88	27	40	64	132	295	335	286	227	217	2103
7 WEST PENNINES	Manchester	230	144	75	38	39	78	157	267	328	360	336	312	2364
		211	121	58	51	52	96	162	308	259	285	269	262	2134
		276	113	81	23	41	65	128	273	351	281	233	230	2095
8 NORTH WESTERN	Carlisle	245	167	90	50	55	95	171	282	341	373	340	323	2532
		229	145	60	56	51	105	165	306	257	272	266	285	2197
		291	114	96	33	39	76	117	289	411	276	251	244	2237
9 BORDERS	Boulmer	271	206	117	66	68	104	182	282	339	375	345	331	2686
		259	189	98	63	62	96	178	286	246	271	282	290	2320
		291	166	117	41	51	91	142	260	343	304	257	224	2287
10 NORTH EASTERN	Leeming	247	168	87	46	49	88	175	281	346	381	353	323	2544
		223	151	64	48	46	87	172	322	249	288	271	265	2186
		280	121	88	26	38	72	131	280	358	289	235	218	2136
11 EAST PENNINES	Finningley	232	154	78	42	44	81	165	232	341	372	347	315	2403
		229	145	69	48	44	90	166	317	257	291	272	252	2180
		279	121	88	29	40	52	127	289	339	293	235	218	2110
12 EAST ANGLIA	Marham	239	149	73	40	39	71	154	269	341	375	350	317	2417
		226	119	75	48	43	75	146	324	290	315	280	246	2187
		276	113	85	24	33	43	107	282	323	280	222	223	2011
13 WEST SCOTLAND	Glasgow	246	170	93	58	64	111	188	299	352	383	347	329	2640
		236	159	62	62	61	106	198	308	250	257	290	307	2296
		280	152	105	45	59	115	152	309	421	300	260	243	2441
14 EAST SCOTLAND	Leuchars	263	197	109	62	67	109	192	301	354	388	353	333	2728
		249	182	85	65	61	103	199	305	272	276	294	301	2392
		281	146	110	42	57	110	152	284	401	321	274	234	2412
15 N E SCOTLAND	Aberdeen	277	206	120	74	78	127	203	311	362	400	364	347	2869
		262	184	88	67	73	112	203	291	271	276	298	305	2430
		301	167	118	47	70	112	156	282	391	332	284	245	2505
16 WALES	Aberporth	240	170	92	49	45	77	145	235	294	329	317	306	2299
		222	149	71	71	60	87	144	256	223	272	261	261	2077
		272	125	89	28	32	63	118	230	316	266	232	236	2007
17 N IRELAND	Belfast	242	171	92	53	59	99	173	282	329	365	330	320	2515
		207	148	66	62	65	106	173	289	257	278	284	384	2319
		282	145	86	32	52	100	118	276	353	306	283	234	2267

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8.0 ESAM worked example

Introduction

8.1 This example is based on an actual small general hospital built on a sloping site. The hospital:

a. was built at the turn of the century, since when there have been various additions of different design and construction;

b. comprises buildings mostly of cavity construction under a pitched roof: some buildings are heated in the summer;

c. has a new gas-fired steam boilerhouse built in 1974 at one end of the site. Steam and condensate pipework runs externally across the whole site to a number of calorifier rooms. There are also some external distribution mains of LPHW for heating and DHWS from the main calorifier plant room. A second boilerhouse serves the physiotherapy department;

d. has a twin theatre suite: surgical, medical, maternity and geriatric wards; X-ray, OPD and A/E departments, plus the usual administration and catering departments;

e. has a heated volume of 39,400 m^3.

8.2 In this example, all calculations and data refer to one year only – 1988/89. For simplicity, only calculations for the mains steam raising boilerhouse are shown. For completeness, however, the second boilerhouse is included in the energy audit produced in the ESAM assessment of site energy requirement.

Site energy performance analysis

Introduction

8.3 The steps described below are the same as those in Chapter 2, to which reference should be made as necessary. ESAM requires completion of Forms 1 to 19 inclusive; copies of each are included in the Appendix. For illustration, the data referring to this actual worked example has been noted on the relevant forms.

Step 1: Site details

8.4 The site exposure and site degree day area are noted on Form 1. For each boilerhouse, the degree day base (hospital or standard), the site annual degree days, and the site degree days for the heating season are also recorded.

Step 2: Collation of fuel records

8.5 Past boilerhouse fuel records are used to complete Form 2. Consumption of different fuels (in their respective units of supply) is recorded separately, converted to GJ (using the factors in Table 4) and aggregated.

8.6 The degree days, taken from a local weather station, are also recorded on Form 2. Hospital degree days (18.5°C) are used, as the boilerhouse supplies mixed hospital and administrative buildings.

Step 3: Consumption histogram

8.7 The histogram shown in Figure 4 illustrates monthly fuel consumption throughout the year.

Step 4: Actual performance

8.8 The next step is the production of a straight-line graph relating fuel consumption in the boilerhouse to degree days on the site (see Figure 5).

8.9 The scatter of the points makes it difficult to draw an accurate straight line by visual inspection, and regression analysis must be used. This technique is described in Chapter 7, but to provide further guidance, the data noted on Form 3 refers to this worked example. All 12 months have been included in the analysis, as the boilerhouse was not shut down during the summer. The correlation factor calculated here (0.95) is acceptable, thus there is no need to repeat the exercise excluding any "rogue" points.

8.10 Figure 29 has been drawn using the data from this worked example and the regression analysis detailed on Form 3:

a. the actual baseload line has been drawn at a value of 950 GJ/month;

b. the actual performance line has been obtained by inserting x = 0 and x = the maximum degree days per month (464, from Form 2) into the equation:

for x = 0, $y = 950$
for x = 464, $y = (4.7 \times 464) + 950$
$= 3131$ GJ/month

The resultant line on the graph has been drawn between these two points.

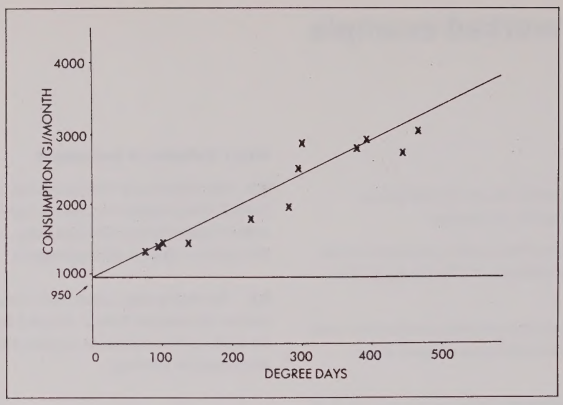

Figure 29 Actual performance (worked example)

Step 5: Average consumption

8.11 The average number of degree days/month

$$= \frac{3156}{12} = 263$$

and average consumption

$$= \frac{26\,310}{12} = 2192 \text{ GJ/month}$$

8.12 These average figures are recorded on Form 3 and the average point may be plotted on the graph showing actual performance (Figure 5).

Step 6: Anticipated consumption

8.13 Combining Figures 4 and 5 provides a profile of consumption with degree day variation, by projecting lines across from the actual performance line of the year just completed onto the histogram. This is described in Chapter 2 and graphically summarised in Figure 6. The analysis can serve as a prediction of consumption for the whole of the current year, and can provide a direct comparison of actual and predicted consumption as the year progresses.

Assessed baseload analysis

8.14 The actual baseload indicated by the regression analysis should now be compared with an assessed baseload. This is obtained by working through steps 7–11, using Form 4 to record the data. A completed Form 4 is provided in the Appendix and should be referred to as each step is carried out.

Step 7: Boilerhouse efficiency

8.15 In this example, the annual boilerhouse efficiency has been properly assessed at 75% by measurement.

Step 8: DHWS load

8.16 For 1988/89 cold water consumption totalled 47,072 m^3, equating to an average monthly consumption of 3923 m^3 for the whole site.

8.17 The water meters installed at each DHWS calorifier give a total monthly consumption of 1600 m^3; the difference in temperature between hot and cold water is 50°C.

8.18 The energy requirement is therefore:

$$\frac{1600 \times 50 \times 1000 \times 4.2}{10^6}$$

$$= 336 \text{ GJ/month}$$

where

the density of water = 1000 kg/m^3;
specific heat capacity = 4.2 kJ/kg/°C.

8.19 The assessed DHWS load on the boilerhouse

$$= \frac{\text{energy requirement}}{\text{boilerhouse efficiency}}$$

$$= \frac{336}{0.75}$$

$$= 448 \text{ GJ/month.}$$

Step 9: Ancillary steam load

8.20 Form 5 in the Appendix has been completed for all items consuming ancillary steam, using actual values based on the typical usages in Table 6.

8.21 The total consumption from Form 5 is 25,170 kg/month. Assuming an average boiler enthalpy rise of 2304 kJ/kg (this figure may be used for all hospital sites), the energy requirement is:

$$\frac{25\,170 \times 2304}{10^6}$$

= 58 GJ/month.

8.22 The assessed load on the boilerhouse due to the ancillary steam use

$$= \frac{\text{energy requirement}}{\text{boilerhouse efficiency}}$$

$$= \frac{58}{0.75}$$

= 77 GJ/month.

Step 10: Circulation and distribution losses

8.23 Since the site is long, with exposed pipework, the circulation and distribution losses have been estimated from Table 8 at 12% of the average consumption.

8.24 Multiplying by the average monthly consumption (from Form 3), the energy loss due to circulation and distribution

= 0.12 x 2192
= 263 GJ/month.

8.25 The assessed load on the boilerhouse due to circulation and distribution losses

$$= \frac{\text{energy requirement}}{\text{boilerhouse efficiency}}$$

$$= \frac{263}{0.75}$$

= 351 GJ/month.

Step 11: Total assessed baseload

8.26 The results from steps 7 to 10 are recorded on Form 4. The data may then be plotted graphically to compare actual and assessed baseloads as in Figure 7.

8.27 Figure 30 has been drawn using the data from the worked example. The assessed baseload is made up of the following components:

	GJ/month
DHWS	448
Ancillary steam	77
Distribution/circulation	351
	876

The total assessed baseload of 876 GJ/month is somewhat lower than the actual baseload of 950 GJ/month.

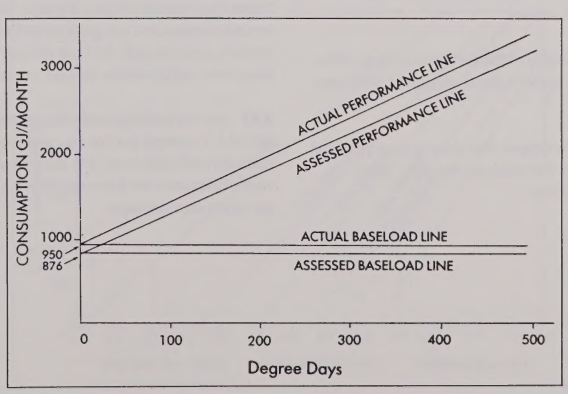

Figure 30 Actual and assessed performance (worked example)

Step 12: Assessed space heating performance

8.28 All the buildings supplied by the boilerhouse, together with their measured heated volumes, are itemised on Form 6. For each building, a heat loss/unit volume is selected from Table 9, according to its construction, ceiling height and percentage glazing. These values are also entered on Form 6, together with the calculated heat loss from each building and the boilerhouse in total. The space heating factor is then

$$= \frac{\text{heat loss (kW)} \times 3600 \times 24}{(\text{DD base temp} - \text{design temp}) \times .10^6 \times \text{efficiency}}$$

$$= \frac{786 \times 3600 \times 24}{(18.5 - [-1]) \times 10^6 \times 0.75}$$

$$= 4.6 \text{ GJ/DD}$$

This figure, which is the slope of the assessed performance line, is also recorded on Form 6.

8.29 Using this data, and the maximum degree days per month in the straight-line equation,

$$y = mx + c$$

where

y = consumption (GJ/month);
m = slope (4.6 from Form 6);
x = degree days (464 from Form 2);
c = baseload (876 from Form 4);

then:

$$y = (4.6 \times 464) + 876$$
$$= 3010 \text{ GJ/month.}$$

8.30 Plotting this point on the graph and connecting it to the intersection of the assessed baseload line with the vertical axis, produces the assessed performance line shown in Figure 30.

Step 13: Performance analysis

8.31 The assessed baseload of 876 GJ/month equates to 92% of the actual baseload total of 950 GJ/month as calculated by regression analysis.

8.32 In addition, the slopes of the performance lines differ slightly, indicating that control is reasonably good, with little overheating.

8.33 The above factors suggest that there is some potential for savings, principally in the baseload, through "good housekeeping" or investment.

Support material

8.34 Enmats;
Enbuild;
Enplant.

Assessment of site energy requirement

8.35 The analysis contained in the previous section is now repeated in more detail with all values being more rigorously calculated.

Step 1: Boilerhouse survey

8.36 The boilerhouse details are obtained and recorded on Form 7; a separate form should be used for each boilerhouse.

Step 2: Assessed baseload

8.37 The baseload data previously calculated in the site energy performance analysis is re-assessed but using accurate measurements in place of norms or best estimates. Form 8, which records the same data as Form 4, is completed to differentiate between the accuracy of the two procedures.

8.38 It is particularly important to calculate an accurate value for boilerhouse efficiency. In the site energy performance analysis the efficiency of the main boilerhouse was assessed as 75%: this ratio is now formally checked and found to be correct.

8.39 Similarly all baseload components should be re-assessed using accurate measured values. In this worked example, it is assumed that the assessment in the previous section was carried out using the best information available, and those figures have therefore been re-used.

Step 3: Building survey

8.40 Once all the buildings have been surveyed, the details (type of construction, floors, ceiling heights, etc) are recorded on Form 9 using a separate copy of the form for each building.

8.41 If the heated volumes used in the previous section (Form 6) are thought to be unreliable, they should be accurately measured using the definitions in Chapter 7. Similarly, external wall, roof and ground floor areas must be taken from reliable estate records, or measured.

8.42 For the building used in this example, an air change rate of 1.5 changes per hour is considered to be average for a naturally ventilated ward. The plant response rate for hot water radiators is medium and the ward is occupied 24 hours per day, 7 days per week.

8.43 The construction details for the external wall, roof and ground floor are also noted. The building in this example has an unusual construction:

a. walls – 13 mm timber cladding on a 105 mm brick wall, with 25 mm glassfibre infill and interior plaster;

b. roof – the flat roof has three layers of felt on 25 mm chipboard, with a 25 mm fibreglass quilt and 13 mm plasterboard.

(These fabrics are not included in Tables 10 and 11 so the U values used have been calculated as described in the CIBSE Guide A3. The U value for the solid floor, however, is taken from Table 12.)

Step 4: Heating systems survey

8.44 The details of the heating systems and controls for each building are recorded on Form 10A, with a sketch of the layout on Form 10B.

Step 5: Assessed space heating performance

8.45 The annual heat loss for each building is calculated from the details recorded on Form 9 and entered onto Form 11 using one copy of the form for each building. The procedure for the adult acute ward building is described below:

a. external walls – this building has only single glazing with a U value of 5.6, so the heat loss can be read off from the appropriate nomogram; in this case, that for single glazing and hospital degree days (Figure 20). Superimposing additional data on that figure results in Figure 31 on which an interpolated 45% line has been drawn between the 40% and 50% lines. The heat loss factor corresponding to the wall U value of 0.95 is 0.9 GJ/annum m^2. This value and the external wall area are entered on Form 11;

b. roof – using the same nomogram and reading from the 0% glazing line, the heat loss factor corresponding to the roof U value of 0.77 is 0.23 GJ/annum m^2. This value, and the roof area, are recorded on Form 11;

c. ground floor – the heat loss factor for the floor U value of 0.3 (hospital degree days) is taken from Table 12. This value (0.089 GJ/annum m^2) and the floor area are recorded on Form 11;

d. ventilation – the heat loss factor for an air change rate of 1.5 (hospital degree days) is taken from Table 13. This value (0.073 GJ/annum m^2) and the heated volume are recorded on Form 11;

e. intermittent heating factor – this is taken from Table 14 according to the type of construction, plant response rate and occupancy values recorded on Form 9. This value (1 in this example) is recorded against each element on Form 11.

8.46 The annual heat loss for each element and the total heat loss are calculated as shown on the form applying the degree day correction, using the formula given and the data on Form 1 for the boilerhouse supplying the building.

8.47 Form 11 is now complete for the adult acute ward. Repeat the process for all other buildings.

Step 6: Building heat loss summary

8.48 The degree day corrected heat losses of all the buildings are recorded on Form 12 and totalled. A separate copy of the form should be used for each boilerhouse. In this example, the total heat loss for the main boilerhouse is 9868 GJ/annum.

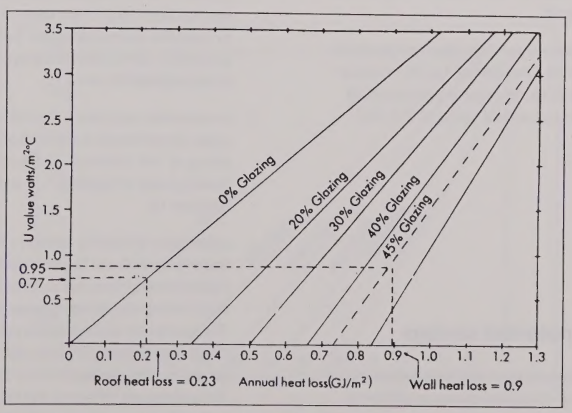

Figure 31 Determination of heat loss through fabric

Step 7: Energy audit balance sheet

8.49 Form 13 should be completed for each boilerhouse by:

a. entering the efficiency and monthly baseload from Form 8 and multiplying the baseload by 12 to give the annual figure;

b. entering the degree day corrected heat loss from Form 12 and dividing by the efficiency to give the annual heat load;

c. dividing the heat load by the boilerhouse degree days from Form 1 to give the space heating factor in GJ/DD;

d. adding the heat load and baseload to give the total assessed load;

e. entering the actual energy consumption from Form 2.

8.50 The sum of these values for all the boilerhouses gives a total value for the site. In this example, to complete the site audit, the details for the second boilerhouse are included. The potential saving is the difference between actual consumption and the assessed load.

Step 8: Performance analysis

8.51 The re-assessed baseload and space heating performance lines are now superimposed on the consumption v. degree day graph produced in Chapter 2 (Figure 11).

8.52 The space heating factor of 3.93 GJ/DD is lower than the assessment made in paragraph 8.28 of 4.6 GJ/DD. This indicates a need to investigate temperature control and level plus boilerhouse efficiency, and demonstrates the value of more rigorous calculations. Such calculations serve to indicate the potential for greater savings, justifying an in-depth investigation of energy-saving measures, of which the assessment of potential savings is an example.

8.53 The assessed baseload, however, is unchanged. The comments on the results of the analysis in the previous section therefore still apply.

8.54 Overall, the balance sheet from this example shows a potential saving of 2758 GJ/annum or 10.0% of actual consumption. In financial terms, assuming a fuel cost of £3.75/GJ, this represents an annual saving of £10,342.

Support material

8.55 Enbuild;
Enplant;
Enaudit;
CIBSE Guide.

Assessment of potential savings

8.56 This section demonstrates how the effect of energy-saving measures may be calculated before an efficiency programme is carried out.

Note: The measures chosen to illustrate the process in this example are not necessarily economically viable – that decision will not be made until the planning stage (see Chapter 3).

8.57 It should be remembered that some measures are dependent on others. Hence, the order in which measures are assessed and their savings are calculated, is important. For example, an improvement in boilerhouse efficiency will affect the savings achieved by other measures in buildings served by the boilerhouse.

8.58 In this example, in order to demonstrate this interdependence, the measures are presented in sequence, and the effects of early measures are carried forward. The resultant savings have been apportioned between space heating load and baseload as appropriate.

8.59 For simplicity, only savings in the main boilerhouse are shown, but in practice separate forms should be used for each boilerhouse.

Step 1: Good housekeeping and low cost measures

8.60 Form 15 should be used to record the measures and savings for each boilerhouse.

8.61 It is estimated that 240 GJ/annum (approximately 1% of actual consumption) could be saved by encouraging staff (lay and estates) to close windows and use hot water wisely. This saving has been equally apportioned between the space heating load and the baseload. It would be hoped that, in practice, savings considerably greater than 1% could be achieved.

a. air infiltration reduction – a reduction in air infiltration may be achieved by draughtproofing the windows and doors. Assuming this reduces the air change rate from 1.5 to 1.0, the potential heat saving can be calculated. On Form 14 the heat loss factor for the new air change rate has been taken from Table 13 (0.049 GJ/annum m^3) and the saving calculated. Savings can be similarly achieved in some other buildings, the total savings being recorded on Form 15;

b. temperature reduction – it is estimated that reducing space temperatures in non-critical areas will give a saving of 141 GJ/annum (4.4% of the assessed space heating loads in Buildings 1, 7 and 8). This is recorded on Form 15;

c. adjustment of heating controls – the space heating controls can be re-scheduled by adjustment, replacement of time clocks, installation of thermostats, or by mixing and diverting valves and steam valves. The savings are expressed as a percentage of the actual space heating load. The assessed space heating losses, for any building noted on Form 12, can be divided by the boilerhouse efficiency and taken as reasonable approximations to the actual load.

In this specific example, it is considered that a 5% saving can be achieved in the adult acute ward, giving an energy saving of 50 GJ/annum. Savings can be similarly achieved in Buildings 3 and 9 as shown on Form 15;

d. effect on distribution and circulation losses – the savings in consumption derived above will lead to a reduction in circulation and distribution losses, as this is calculated as a percentage of the total consumption. Form 15 shows the calculations;

e. summary – the savings are aggregated and the revised baseload, heat load and total consumption are calculated by subtraction of the savings from the actual values recorded on Form 3. The data from this worked example identifies a saving of 1346 GJ/annum. This compares with the potential saving of 2641 GJ/annum indicated by the assessment of site energy requirement analysis. The simple good housekeeping measures above have thus achieved half of this potential saving; further good housekeeping measures may realise even more.

Step 2: Capital investment – boilerhouse improvements

8.62 Only energy efficiency measures within the main boilerhouse have been examined.

8.63 A full investigation of the boilerhouse was carried out and it was found that the burners needed to be renewed and the combustion chamber relined. (This may be considered as major maintenance.) These changes will increase efficiency by 2% to 77%.

8.64 The energy savings from these measures will be reflected in both the baseload and the space heating load. These have been calculated on Form 16.

Step 3: Capital investment – improvements to buildings

8.65 The details of heat savings through modifications to the building structure have been recorded on Form 17. In this example, the effect on the adult acute ward (Building 2) only is shown, and no new controls have been included as they were dealt with as a good housekeeping measure. For each element, the nature of the structural change has been recorded. The area/volume, the intermittent heating factor, the original heat loss (from Form 11) and the new potential boilerhouse efficiency (from Form 16) have all been carried over onto Form 17.

a. external wall insulation – insulating the external walls with a 25 mm polystyrene/13 mm plasterboard laminate would reduce the U value from 0.95 to 0.50.

Whereas a wall U value of 0.95 has been shown to give a heat loss of 0.9 GJ/annum m^2 (Step 5), insulated walls with a U value of 0.5 reduce the heat loss to 0.82 GJ/annum m^2. This is shown graphically in Figure 32. Again the heat loss assumes 45% glazing. The new heat loss is recorded and the potential heat saving calculated and divided by the boilerhouse efficiency to give the energy saving;

b. flat roof insulation – similarly, insulating the external surface of the flat roof with 40 mm felt-backed polystyrene would reduce the roof U value from 0.85 to 0.48. The new heat loss factor of 0.14 GJ/annum m^2 and the corresponding energy savings have been recorded on Form 17.

These values have been summated to give the total for both modifications to the building structure.

Similar measures were applied to Buildings 1, 3, 6 and 9. The equivalent Form 17 for these is not included in this manual, but the effects have been shown on Forms 18 and 19;

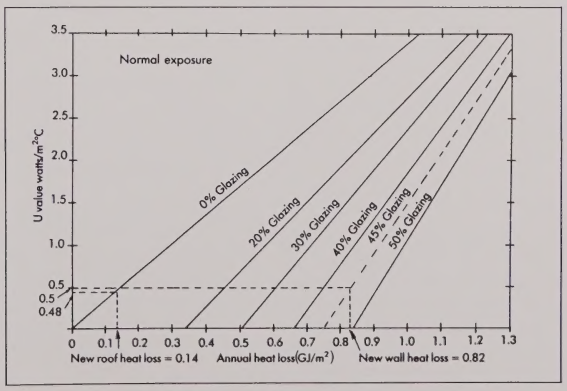

Figure 32 Determination of revised heat loss through fabric

c. improvements to controls – the OPD section of Building 5 has been provided with zone and time controls to match the hours of occupation. The details are recorded on a second copy of Form 17 using heat losses taken from the Form 11 prepared for this building but not shown;

d. effect on distribution and circulation losses – these savings will lead to a further reduction in the distribution and circulation load as noted in Step 1. This saving has been calculated and is shown on Form 17.

Step 4: Summary

8.66 All capital measures and their energy savings are summarised on Form 18. The building improvements suggested for the adult acute ward have also been applied to other buildings on site and the pro-rata energy savings shown on the form. The revised heat load, baseload and total load have been calculated.

8.67 All measures (both good housekeeping and capital investment) are transferred to Form 19. Where there is more than one boilerhouse, the savings for all boilerhouses should be summarised on this form. Revised baseload, heat load and total consumption have also been entered on Form 19 to take account of all measures and their savings (including those for Buildings 1,3, 6 and 9).

8.68 Each energy-saving measure has been multiplied by the fuel cost to give the annual cost saving, and these are then totalled. Good housekeeping measures show a potential saving of £5048, and capital investment measures a further saving of £11,894, giving a total of £16,942. If these measures were implemented, annual fuel consumption could potentially be reduced from 26,310 to 21,792 GJ/annum, a saving of 17.3%.

8.69 Thus, from this worked example, it would appear that the implementation of the good housekeeping measures described above would bring about worthwhile savings in both energy and expenditure.

8.70 The capital investment measures, while potentially showing higher savings, will need to be the subject of a detailed investment appraisal to establish their financial viability.

Support material

8.71 Encost;
Encode 2;
Encomp.

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9.0 Assessment of electricity consumption

Introduction

9.1 This chapter attempts to produce a method for the assessment of the site electrical load against the known occupancy and installed plant and equipment.

9.2 Although electricity is the most expensive fuel in terms of £/GJ at the incoming meter, its consumption in the NHS is increasing faster than the national average. The increase in use is such that for many health authorities, expenditure on electricity is fast approaching one-half of the total energy bill.

9.3 While the use of fossil fuels is in the control of a few trained people who can exercise considerable care in consumption, practically every member of staff is able to use or misuse electricity. The problem is exacerbated by increased use of small items of power equipment, for example computers, patient support medical machines, electronic equipment and refrigeration plant.

9.4 Although certain assumptions may be open to discussion, it should be recognised that the method described is a "broad brush" technique aimed at the energy manager, who may not have sufficient time to evaluate lengthy calculations. As this material has not been previously published, any comment from users will be welcomed.

9.5 The basic concept is to follow the ESAM philosophy but adapting the method for electrical use by assessing site electricity consumption and comparing the result with actual consumption obtained from, in this case, monthly bills.

9.6 Again, the procedure may be divided into three parts:

(i) site electrical performance analysis;

(ii) assessment of site energy requirement;

(iii) assessment of potential savings.

9.7 Forms for recording electricity usage are included in the Appendix.

Site electrical performance analysis

9.8 As before, histograms logging monthly consumption and maximum demand need to be drawn from the data previously entered on Form E1. These should be examined by the energy manager to identify any trends in seasonal consumption, occupancy patterns and perhaps abnormal peak loads. It may be possible to establish a baseload, dependent upon the amount of seasonal loading used on the site.

9.9 Comparison of year-by-year histograms will also illustrate any change in total consumption, as well as maximum demand, which also needs to be monitored.

9.10 It is likely that only total site metering is available. Of more use is data from each block or group of buildings, which might identify high consumers. This requires sub-meters, which are not always installed. However, where provision cannot be made for sub-meters, spot checks may be possible by hiring meters to record peak demand; these can be fitted to the sub-distribution board, or to the sub-mains. Thus consumption in specific areas such as kitchens or wards could be recorded and assessed independently. The local electricity supplier may be able to help by lending such test equipment.

Assessment of site electrical requirement

9.11 To quantify heat losses, the survey could be carried out on a building or block basis. This might follow the segregation already decided upon for the heat loss survey or, by necessity, it may need to correspond with the electrical distribution system. One advantage of an electrical survey is that consumption can be checked through the temporary connection of recording equipment producing a load profile over a set time period.

9.12 The types of load may be split into the following categories:

a. lighting;

b. power – portable equipment;

c. power – fixed equipment;

d. catering equipment;

e. lifts;

f. plant;

g. other.

9.13 The examples below are for a 24-hour period. The same method may be applied but the assessment should be converted to a monthly figure for comparison with electricity suppliers' bills.

Lighting

9.14 The most comprehensive way to assess the amount of electric lighting likely to be used is to base calculations on a "daylight factor" as defined in British Research Establishment (BRE) Digests 41 and 42. However, this method would be extremely lengthy when applied to a hospital site, as each individual room would have a unique daylight factor dependent upon orientation, amount of glazing, surface reflection and external shadowing.

9.15 Therefore, a simple "diversity factor" has been developed which seeks to represent the natural light available in a room and hence the likelihood of artificial lighting being switched on. It is a fairly crude method but is at least one that can be easily applied.

9.16 Two extremes are defined, and the surveyor must decide on an appropriate factor within the available range that is representative of the room or group of rooms:

(i) dull room with low reflectances, small windows with some external shading and predominantly north-facing, that is, worst case when the lights have to be on continuously:

diversity factor (f) = 1.0;

(ii) light room with high reflectances, large windows and no shading, predominantly south-facing, that is, best case, during hours of daylight:

diversity factor (f) = 0.4.

9.17 It is assumed that a lighting level of approximately 300 lux is required and that even in a very bright room, lighting will be required for some of the day.

9.18 The surveyor also needs to record the type and number of luminaires in a given area, calculate the maximum load in kW and enter the figures on Form E2. Gear losses in fluorescent and discharge fittings should be allowed for, that is, a 1500 mm 65/80 W fitting actually consumes 112 VA per luminaire.

9.19 Occupancy details are also required in order to assess the anticipated kWh. With office and day use accommodation, in an out-patient department for example, the task is fairly simple, as occupancy and daylight hours are the same. Ward areas, however, must be treated separately as there are three distinct time periods when the lighting may be on or off:

(i) morning and evening, that is, dusk and dawn, when all lights could be switched on;

(ii) daylight hours, when some lights may be switched on throughout the ward and ancillary rooms;

(iii) hours of darkness, when the ward area will be lit by night-lights only and ancillary rooms by part normal lighting.

Wards

9.20 In the ward areas, lighting requirements reflect the number of daylight hours rather than occupation. This is best illustrated in an example:

100 fluorescent fittings: 1500 mm, 65/80W, of which 80 are fitted with 15W pygmy lamps as night-lights.

9.21 The ward is not particularly light and so a diversity factor of 0.6 is selected. However, during the morning and evening when the daylight is poor the diversity factor must be 1.0, that is, the lights are on continuously.

9.22 Two examples are given, one in June and one in December:

June

Lighting	Diversity factor	Occ. hrs	Total (kWh)
100 x 112 = 11.2 kW	0.6	daytime: 14	94.08
100 x 112 = 11.2 kW	1.0	evening: 2	22.40
(20 x 112) + (80 x 15) = 3.4 kW	1.0	darkness: 8	27.20
			143.68

December

Lighting	Diversity factor	Occ. hrs	Total (kWh)
100 x 112 = 11.2 kW	0.6	daytime: 8	53.76
100 x 112 = 11.2 kW	1.0	evening: 8	89.60
(20 x 112) + (80 x 15) = 3.4 kW	1.0	darkness: 8	27.20
			170.56

9.23 It can be seen that consumption in December is 19% higher than in June, which may be a fair representation but is obviously dependent upon the subjective assessment of the surveyor. Nonetheless, if an average is taken of these two extreme months this assessment can also be used for spring and autumn. Thus an assessment for the whole year can be provided from only two surveys.

9.24 It should be noted, however, that no account has been taken of the effects of power factor in these calculations.

Power

9.25 Assessments of electricity consumption by portable and fixed equipment, catering equipment, lifts, plant and other electrical equipment are all noted on form E3.

Portable equipment

9.26 Assessment of the portable equipment connected to the ring main can only ever be a snapshot of likely consumption. All that can be done is to survey, note the connected equipment and ascertain average use; for example in the general office the assessment may look like this:

Equipment	No.	Load (kW)	Diversity	Hrs used	Total (kWh)
Photocopier	1	1.5	0.5	8	6.00
Typewriter	4	0.3	0.8	8	7.68
VDU	10	0.4	1.0	5	20.00
					33.68

9.27 This can be a tedious task but could be very rewarding as the use of electricity for such equipment is probably growing at the fastest rate.

Fixed equipment

9.28 Similar principles apply to assessing fixed equipment except that this is likely to include electric heaters, where actual hours of use are very difficult to ascertain as they obviously depend on temperature.

9.29 If a building is heated solely by electricity, the assessment of electricity consumption should be based on the methods outlined in Chapter 2 for heat losses rather than counting the number of heaters fitted, that is, based on total fabric and ventilation losses.

9.30 The difficulty lies in assessing consumption hours for electric heaters used as a "top-up" to an inadequate wet system, or used during autumn and spring months for background heating. It is not difficult to base an assessment upon degree days and therefore external temperature where no other source of heat is installed, but the electricity consumption of heaters used as a "top-up", or as background heating, is dependent upon internal temperature and hence other heating sources.

9.31 One possibility is to simply record the switching pattern of the heater thermostat over, say, a 10-minute period and multiply by the hours in use. This approach may also be used for other portable items, such as those which may be found in an out-patient department:

Equipment	No.	Load (kW)	Diversity	Hrs used	Total (kWh)
Convection heater	2	2.0	0.5	6	12.0
Radiant heater	6	1.0	0.5	1	18.0
X-ray viewers	6	0.15	1.0	1	0.9
					30.9

Catering equipment

9.32 Almost all electrical catering equipment is controlled by a thermostat or similar temperature-dependent device. This again makes assessment of actual consumption very difficult. Studying switching patterns of individual equipment is one possible method, but alternatively, a recording instrument may be used over an hourly period and then used to calculate total consumption for actual catering hours.

9.33 As before, the surveyor needs to list equipment, record the power rating, hours in actual use, and then select a diversity factor that takes switching into account. For the main kitchen the assessment may look like this:

Equipment	No.	Load (kW)	Diversity	Hrs used	Total (kWh)
Solid top	2	9	0.6	5.0	54.0
Convection oven	1	6	0.7	4.5	18.9
Grill	1	1	1.0	1.0	1.0
Cold room	2	0.5	0.7	24.0	16.8
					90.7

Lifts

9.34 Compared with the total electricity consumption of a building, that used by lifts is small. It varies from approximately 0.5% for a low-rise building to approximately 3% for a high-rise building. The following table gives average daily consumption.

Contract load (kg)	Energy consumption at various contract speeds (m/s) in MJ/day 0.75	1.0	1.5	2.5	3.5
600	60	80	100	–	–
900	70	90	120	180	240
1200	80	100	130	190	250
1500	90	110	140	200	260
1800	–	–	150	210	270

9.35 The surveyor should use this data to obtain an assessment of daily electricity consumption and then convert to a monthly total.

Plant

9.36 Environmental plant can form a large electrical load on a hospital site. Constant loads such as circulating pumps are easy to assess, but temperature-controlled motors for refrigeration plant, burners and fans are more difficult to analyse.

9.37 As with other similar equipment, consumption may be monitored over a short period and then totalled to give representative usage.

9.38 Predicting energy consumption for air-conditioning loads is particularly difficult and no accurate method has yet emerged; however, in most hospitals plant loads will be small by comparison and therefore any error will be insignificant.

Other electrical equipment

9.39 This category covers electrical equipment not specifically described elsewhere, although some items could be included in the fixed equipment category, for example X-ray equipment, telephone switchgear, radio receivers/transmitters. Other medical equipment such as diathermy and vacuum units could be included under portable equipment.

9.40 In all cases the same routine applies:

- survey;
- count;
- assess load;
- note hours of expected use;
- total to give kWh.

Total load

9.41 Form E4 should be used as a summary sheet for recording the assessed totals and the actual consumptions.

Assessment of potential savings

9.42 The balance sheet produced by the survey method will contain information requiring analysis in order to identify potential savings. As before, these will fall into two categories, as below.

Difference between assessed and actual electrical consumption

9.43 This category generally reflects the saving potential from "good housekeeping" measures by both lay and estates staff. For example:

- encouraging users to switch off lights, catering equipment, etc;
- reviewing tariffs and seeking advice if necessary;
- balancing phases to reduce peak demand;
- power factor correction;
- examining temperature set-points on refrigeration loads.

Investment

9.44 Inefficiency may be manifested in the following ways:

- lights not switched off during the occupancy period and excessive lighting levels;
- catering equipment switched on outside actual hours of use;
- illicit electrical heating over and above that provided;
- equipment brought onto the site and not accounted for.

9.45 These potential savings will probably have been identified during the survey using Form E5, and might require the installation of:

- automatic lighting and ventilation controls timed for occupancy or fitted with presence controls;
- high-efficiency lamps and reflectors. Colour correction needed in clinical areas;
- time switches on catering equipment in general;
- a more widespread wet heating system to allow disposal of electric heating;
- variable speed, set back and time controls to ventilation fans.

9.46 Completion of this survey will enable an energy manager to adopt more electricity-saving measures. The energy efficiency booklets issued by the Department of Energy cover this subject and are worth studying, while the forms used for ESAM could easily be adapted to allow this section to be tabulated.

Support material

9.47 BRE Digests 41, 42;
CIBSE Guide;
CIBSE Applications and Technical Manuals.

Glossary

Baseload – the load on a boilerhouse which is constant throughout the year.

Benefit cost ratio (BCR) – the ratio of the net present value of benefits to the net present value of costs.

Building Management System (BMS) – computer-based system which can be used to manage the operation of mechanical and electrical plant and collect data on performance.

Correlation coefficient – a measure of the degree of scatter of plotted points on a graph. The coefficient quantifies the extent to which the relationship between these points is linear.

Daylight factor – the ratio of the horizontal illumination measured at a main point in a room, to the horizontal illumination from the whole sky, excluding sunlight, measured simultaneously. It is related to a given position within a room.

Degree days (DD) – a means of measuring outside temperature from a given base of either 18.5°C or 15.5°C.

DHWS – domestic hot water service. Water stored at not less than 60°C to provide hot water for washing and bathing.

Diversity factor – the amount of time allowed for use of energy against the period the equipment may be in operation.

ESAM – the Energy Survey and Audit Method described within this manual.

GigaJoules – 10^9 Joules. A Joule is a Watt/sec.

High pressure hot water (HPHW) – water under pressure whose temperature exceeds 100°C.

Low pressure hot water (LPHW) – a system which is open to atmosphere whose temperature does not exceed 100°C.

Net present value (NPV) – the value of a future cost or saving discounted back to the present.

Performance indicator – a means of comparison against a base.

Regression analysis – a mathematical method of calculation to determine the position of a straight line connecting scattered points on a graph.

Space heating load – that part of the boilerhouse load used for space heating which varies according to the weather.

U value – the value for the thermal transmittance of a building element. It is measured in Watts per sq m deg C ($W/m^2 °C$).

Encode computer programs

Enaudit: provides facilities to gather and record data on current and estimated energy usage.

Enbuild: builds up an energy profile of a site and provides facilities to assess the boilerhouse energy requirements for space heating. Can be used as a modelling tool.

Encap: utility meter reading system based on a Psion hand-held computer.

Encomp: energy conservation model using payback and break-even time as the criteria. Creates a programme to implement the proposed changes.

Encost: a more sophisticated program which provides facilities to specify future and recurring capital, revenue and energy costs. Requires more detail than Encomp. Creates a programme to implement the proposed changes.

Enmats: energy monitoring and targeting system. Provides facilities for regression analysis and allows the baseload and space heating characteristics to be derived from recorded consumption. Assists in monitoring fuel consumption and cost.

Enplant: assists in the calculation of the baseload of each boilerhouse.

Standard Stationery

ESAM Part 1 Site details	FORM 1 Date: MAY 1989

Health Authority: ..... Hospital: WORKED EXAMPLE

Year: 1988/89

Site Degree Day area: ANYSHIRE

Site exposure[1]: NORMAL

Boilerhouses

Name	Degree Day Base (Hospital/Standard)	Annual Degree Days[2]	Heating Season Degree Days[3]
MAIN	HOSPITAL	3352	3352
PHYSIOTHERAPY	HOSPITAL	3352	3016

Comments: (e.g., boiler sequencing, seasonal shutdown, etc.)

Notes:

(1) Sheltered, Normal or Severe. See CIBSE GUIDE A3.

(2) The 20 year site average for the Degree Day Base specified.

(3) As above, less the Degree Days for those months when the heating is turned off.

Standard Stationery

ESAM Part 1 — **FORM 2**

Record of monthly fuel consumption and Degree Days — Date: MAY 1989

Health Authority: ..... Hospital: WORKED EXAMPLE

Boilerhouse: MAIN Year: 1988/89

	Fuel	Units	Factor to Convert to GJ
1.	NATURAL GAS	THERMS	x 0.1055
2.	32 SEC OIL	LITRES	x 0.0381
3.			

Month	Fuel consumption (units of supply) Fuel 1	Fuel 2	Fuel 3	Total consumption (GJ)	Degree Days (Hospital/ ~~Standard~~)[1]
APR		65879		2510	297
MAY		47191		1798	226
JUN		37690		1436	98
JUL	12445			1313	72
AUG	12980			1370	95
SEP	13990			1476	133
OCT	18834			1987	267
NOV		75643		2882	297
DEC		72283		2754	442
JAN		73465		2799	377
FEB		80079		3051	464
MAR		77008		2934	388
TOTAL	58249	529238		26310	3156

Notes:
[1] Delete as applicable

ENCODE

Standard Stationery

ESAM Part 1 Analysis of actual performance	FORM 3 Date: MAY 1989

Health Authority: ..... Hospital: WORKED EXAMPLE

Boilerhouse: MAIN Year: 1988/89

	Month	Consumption[1] (GJ) y	Degree[1] Days x	$xy \div 10^6$	$y^2 \div 10^6$	$x^2 \div 10^6$
1	APR	2510	297	0.745	6.300	0.088
2	MAY	1798	226	0.406	3.232	0.051
3	JUN	1436	98	0.141	2.062	0.010
4	JUL	1313	72	0.095	1.724	0.005
5	AUG	1370	95	0.130	1.877	0.009
6	SEP	1476	133	0.196	2.179	0.018
7	OCT	1987	267	0.531	3.948	0.071
8	NOV	2882	297	0.856	8.306	0.088
9	DEC	2754	442	1.217	7.585	0.195
10	JAN	2799	377	1.055	7.834	0.142
11	FEB	3051	464	1.416	9.309	0.215
12	MAR	2934	348	1.138	8.608	0.151
TOTAL		26310	3156	7.926	62.964	1.043
Exclusions:						
NEW TOTAL						

(2)

$K = \Sigma(x^2)10^6 - \frac{(\Sigma x)^2}{n}$ = 212972

$L = \Sigma(y^2)10^6 - \frac{(\Sigma y)^2}{n}$ = 5279525

$M = \Sigma(xy)10^6 - \frac{\Sigma x \Sigma y}{n}$ = 1006470

Correlation = $\frac{M}{\sqrt{K \times L}}$ = 0.95

Actual space heating factor = $\frac{M}{K}$ = 4.7 GJ/DD

Actual monthly base load = $\frac{\Sigma y - \frac{M \Sigma x}{K}}{n}$ = 950 GJ/month

Average Degree Days/month = 263 DD/month

Average consumption/month = 2192 GJ/month

Annual base load = monthly base load × 12 = 11400 GJ/annum

Annual space heating load = Total consumption − annual baseload

= 14910 GJ/annum

Notes: (1) Taken from Form 2 (2) n = number of months

Standard Stationery

ESAM Part 1 Assessed baseload	FORM 4 Date: MAY 1989

Health Authority: ..... Hospital: WORKED EXAMPLE

Boilerhouse: MAIN ..... Year: 1988/89

Boilerhouse efficiency	75	%
Cold water consumption	3923	m^3/month
Hot water consumption	1600	m^3/month
Temperature difference	50	°C
Ancillary steam consumption	25170	kg/month
Distribution/circulation loss	12	%

	Energy requirement (GJ/month)	Boilerhouse[4] load (GJ/month)
DHWS[1]	336	448
Ancillary Steam[2]	58	77
Distribution/ circulation[3]	263	351
TOTAL	657	876

Notes

(1) Energy requirement for DHWS

$$= \frac{\text{Hot water consumption} \times \text{temperature difference} \times 1000 \times 4.2}{10^6}$$

(2) Energy requirement for ancillary steam

$$= \frac{\text{Consumption in kg/month} \times 2304}{10^6}$$

(3) Energy loss to distribution and circulation

= Distribution/circulation loss × average monthly consumption

(4) Boilerhouse load $= \frac{\text{Energy requirement}}{\text{efficiency}}$

Standard Stationery

ESAM Part 1
Ancillary steam usage

FORM 5
Date: MAY 1989

Health Authority: .....
Hospital: WORKED EXAMPLE
Boilerhouse: MAIN
Year: 1988/89

Equipment	No.	kg/hr	Hrs/day	Days/ month	Cycle diversity	kg/month
BOILING PANS	3	22	5	30	0·5	4950
STEAMING OVENS	1	27	4	30	0·5	1620
AUTOCLAVE	1	41	5	24	0·5	2460
STERILIZER	1	16	5	24	0·5	960
BOWL & INSTR. STERILIZER	1	5	2	24	1·0	240
BED PANS	3	11	2	30	1·0	1980
THEATRE RE-HEAT	1	23	12	24	1·0	6624
THEATRE HUMIDIFIER	2	22	12	24	0·5	6336

Standard Stationery

ESAM Part 1
Assessed heat load

FORM 6
Date: MAY 1989

Health Authority: .....
Hospital: WORKED EXAMPLE
Boilerhouse: MAIN
Year: 1988/89

Bldg. Ref.	Title/Function	Type of construction[1]	Heated volume[2] (m^3) A	Heatloss/unit volume[3] (W/m^3) B	Assessed heatloss (kW) A × B/1000
1	ADMIN BLOCK	BRICK/2"CAVITY/BRICK	3032	20	79
	KITCHEN		2706	20	54
	THEATRE SUITE		1580	20	32
2	ADULT ACUTE WARD	TIMBER/BRICK	1846	30	55
3	TOP BLOCK	BRICK/2"CAVITY/BRICK	10790	20	216
4	PATH. LAB.	ASBESTOS/FIBREBOARD	2017	30	61
5	A & E	BRICK/2"CAVITY/BRICK	3780	20	76
	OPD	— · —	1410	20	28
6	X-RAY	— .. —	3165	20	63
7	STAFF REST.	— .. —	788	36	28
8	COMPUTER SUITE	— · —	477	20	10
9	SURGICAL WARDS	— · —	4217	20	84
		TOTALS	36708		786

Assessed space heating factor[4] = 4.6 GJ/DD

Notes

(1) Identify basic form of construction, eg, Traditional brick/pitched tile roof, System built/flat roof, Prefab asbestos/pitched roof, etc.

(2) Exclude all unheated spaces.

(3) Refer to Table 9 for typical values.

(4) Assessed space heating factor

$$= \frac{\text{Total heat loss} \times 3600 \times 24}{(\text{DD base temp} - \text{design temp}) \times 10^6 \times \text{efficiency}}$$

where DD base temp is 18.5°C for Hospital DDs or 15.5°C for Standard DDs, and design temp = −1°C.

Standard Stationery

ESAM Part 2 Boiler details			FORM 7 Date: MAY 1989
Health Authority:		Hospital: WORKED EXAMPLE	
Boilerhouse: MAIN		Year: 1988/89	
Boilers			
Type	THOMPSON & COCHRANE	THOMPSON & COCHRANE	
Rating	1465 kg/h	2926 kg/h	
Age	1974	1974	
Condition	GOOD	GOOD	
Feed pumps	WORTHINGTON SIMPSON		
	SINGLE STAGE 5.5 HP		
Fuel storage and handling	MAINS GAS		
	HAMWORTHY HSM MK II		
	METER IN METER HOUSE		
Log sheet records	STANDARD		
Blowdown	3 TIMES DAILY		
Water treatment	YES		
Instrumentation and metering			
Flue temperature	✓		
CO_2	✓		
Smoke number			
Water treatment	/		
Hours run	/		
Oxygen	/		

Standard Stationery

ESAM Part 2 Reassessed baseload	FORM 8 Date: MAY 1989

Health Authority: ..... Hospital: WORKED EXAMPLE

Boilerhouse: MAIN Year: 1988/89

The entries on this form should be obtained by a more rigorous procedure than those on Form 4 (ESAM Part 1).

Boiler house efficiency	75	%
Cold water consumption	3923	m^3/month
Hot water consumption	1600	m^3/month
Temperature difference	50	°C
Ancillary steam consumption	25170	kg/month
Distribution/circulation loss	12	%

	Energy requirement (GJ/month)	Boilerhouse[4] load (GJ/month)
DHWS[1]	336	448
Ancillary Steam[2]	58	77
Distribution/ circulation[3]	263	351
TOTAL	657	876

Notes

(1) Energy requirement for DHWS
$$= \frac{\text{Hot water consumption} \times \text{temperature difference} \times 1000 \times 4.2}{10^6}$$

(2) Energy requirement for ancillary steam
$$= \frac{\text{Consumption in kg/month} \times 2304}{10^6}$$

(3) Energy loss to distribution and circulation
= Distribution/circulation loss × average monthly consumption

(4) Boilerhouse load $= \frac{\text{Energy requirement}}{\text{efficiency}}$

Standard Stationery

ESAM Part 2 Building details			FORM 9 Date: MAY 1989
Health Authority:		Hospital: WORKED EXAMPLE	
Boilerhouse: MAIN		Year: 1988/89	
Building Title/Function: ADULT ACUTE WARDS		Building Ref: 2	
Construction[1]	LIGHT	Type of occupancy[4]	WARD
Number of floors	1	Number of days/week	7
Floor to ceiling height (m)	3	Time from	-
Heated volume (m^3)[2]	1846	Time to	-
External wall area (m^2)	472	Number of hours/day	24
Floor area (m^2)	674		
Roof area (m^2)	674		
Air change rate (/hr)	1.5		
Plant response rate[3]	M		

Walls Type	TIMBER FRAME	Notes
Materials/thickness	TIMBER/BRICK 0.27m	
Cavity size	50mm	
Insulation	-	
U value	0.95 W/m^2°C	
Glazing % single	45%	
U value single	5.6	
% double	-	
U value double	-	
Roof Type	Flat/Pitched	25mm FIBREGLASS FELT
Materials/thickness	3 LAYERS OF FELT	25mm CHIPBOARD
U value	0.77 W/m^2°C	13mm PLASTER BOARD
Floor Type	Solid/Ventilated	
Materials/thickness	CONCRETE 150mm	
U value	0.3 W/m^2°C	

Notes

(1) Heavy, Medium or Light.

(2) See Chapter 7 for definitions of measured volumes and areas.

(3) Fast, Medium or Slow.

(4) E.g., Ward, Dining, Admin.

Standard Stationery

ESAM Part 2 Heating system and controls (details)	FORM 10A Date: MAY 1989

Health Authority: ..... Hospital: WORKED EXAMPLE

Boilerhouse: MAIN Year: 1988/89

Building Title/Function: ADULT ACUTE WARDS Building Ref: 2

Form of heating[1]: STEAM/WATER CALORIFIER
TWO PIPE SYSTEM

Circulation mains[2]: SEPARATE CALORIFIERS FOR THIS BLOCK

Insulation:

Heating plant[3]: No 1: RYCROFT CALORIFIERS 63 kW/h
No 2: RYCROFT CALORIFIERS 63 kW/h

Age: APRIL 1975

Heating controls: Buildings[3] SATCHWELL 3/4" STEAM VALVE CONTROLLING HEATER BATTERY COMPENSATING SYSTEM
FLOW & EXTERNAL THERMOSTAT; HIGH LIMIT THERMOSTAT

Age:

Heating controls: Plant[3]

Age:

Notes

(1) Identify type(s) of heating service and form of circulation, e.g., single or two pipe.

(2) Do circulation mains separately serve buildings with mixed occupancy and departments or areas with intermittent occupation.

(3) Identify type and age (if necessary age range) of heating plant and heating controls on the building and plant.

Standard Stationery

ESAM Part 2 Heating system and controls (sketch)	FORM 10B Date: MAY 1989

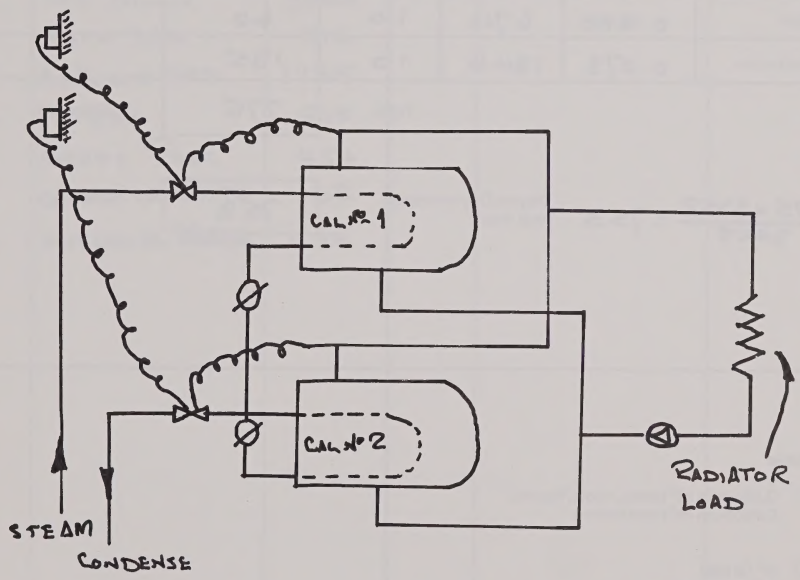
Health Authority: ..... Hospital: WORKED EXAMPLE

Boilerhouse: MAIN Year: 1988/89

Building Title/Function: ADULT ACUTE WARDS Building Ref: 2

Draw a single line sketch of heating system layout, indicating position and type of existing controls, time switches and sensors.

Indicate control manufacturers.



Standard Stationery

ESAM Part 2 Building heat loss assessment	FORM 11 Date: MAY 1985

Health Authority: ..... Hospital: WORKED EXAMPLE

Boilerhouse: MAIN Year: 1988/89

Building Title/Function: ADULT ACUTE WARDS Building Ref: 2

Element	Heat loss factor[1] A	Area/ volume[2] B	Intermittent heating factor[3] C	Heat loss (GJ/annum) D = A × B × C	Notes
Wall	0·9	472	1·0	425	
Roof	0·23	674	1·0	155	
Floor	0·089	674	1·0	60	
Ventilation	0·073	1846	1·0	135	
			Total	775	GJ/annum

$\frac{775 \times 3352}{3448} = 753$ Degree Day corrected heat loss[4] 753 GJ/annum

Notes

(1) GJ/annum m^2 (walls, roofs, floors)
GJ/annum m^3 (ventilation)

(2) m^2 (areas)
m^3 (volumes)

(3) From Table 14

(4) Degree Day corrected heat loss

$$= \frac{\text{Heat loss} \times \text{Boilerhouse Heating Season DDs}}{\text{National average annual DDs}}$$

where the National average = 3448 (for Hospital DDs) or 2462 (for Standard DDs)

Standard Stationery

ESAM Part 2 Summary of assessed heat loss	FORM 12 Date: MAY 1989

Health Authority: ..... Hospital: WORKED EXAMPLE

Boilerhouse: MAIN Year: 1988/89

Building Ref.	Title/Function	DD[1] corrected heat loss (GJ/annum)	Building Ref.	Title/Function	DD[1] corrected heat loss (GJ/annum)
1	ADMIN BLOCK	1864			
2	ADULT ACUTE WARDS	753			
3	TOP BLOCK	3240			
4	PATH LAB	514			
5	A&E AND OPD	1235			
6	X-RAY	508			
7	STAFF REST.	454			
8	COMPUTER SUITE	162			
9	SURGICAL WARDS	1138			
	Sub total	9868		Total	

Notes

(1) From Form 11

Standard Stationery

ESAM Part 2
Energy Audit Balance Sheet

FORM 13
Date: MAY 1989

Health Authority: .....
Hospital: WORKED EXAMPLE
Year: 1988/89

Energy source	B/h eff.	Assessed monthly baseload (GJ/month)	Assessed annual baseload[1] (GJ/annum)	DD corrected heat loss (GJ/annum)	Assessed annual heat load[2] (GJ/annum)	Assessed space heating factor[3] (GJ/DD)	Total assessed annual load[4] (GJ/annum)	Actual energy consumption[5] (GJ/annum)
MAIN BOILER HOUSE	0·75	876	10512	9868	13157	3·93	23669	26310
PHYSIO BLOCK	0·8	26	312	577	721	0·22	1033	1150
TOTALS		902	10824	10445	13878	4·15	24702	27460

Potential saving = actual − assessed: 2758

% saving: 10

Notes

(1) Monthly baseload × 12

(2) $\frac{\text{DD corrected heat loss}}{\text{boilerhouse efficiency}}$

(3) $\frac{\text{Assessed annual heat load}}{\text{Boilerhouse annual DDs (from Form 1)}}$

(4) Assessed annual baseload + assessed heat load

(5) From Form 2

ENCODE

Standard Stationery

ESAM Part 3 Draught Proofing	FORM 14 Date: MAY 1989

Health Authority: ..... Hospital: WORKED EXAMPLE

Boilerhouse: MAIN Year: 1988/89

Select the heat loss factor for the new air change rate from Table 13 and calculate the saving as shown and enter on Form 15.

Building Ref.	Heat loss factor (GJ/annum/m^3) A	Volume (m^3) B	Intermittent heating factor C	New heat loss (GJ/annum) D = A × B × C	Original heat loss (GJ/annum) E	Heat saving (GJ/annum) F = E − D	Boiler house efficiency % G	Energy saving (GJ/annum) H = F/G	DD(1) corrected energy saving (GJ/annum) J
B2	0·049	1846	1	90	135	45	0·75	60	58
OTHERS	–	–	–	–	–	–	–	–	421

GJ/annum

Total Saving 479

(1) Degree Day corrected energy saving

= Energy saving × Boilerhouse Heating Season DDs / National average annual DDs

Standard Stationery

ESAM Part 3 — **FORM 15**

Summary of Good Housekeeping energy savings

Date: MAY 1989

Health Authority: .....

Hospital: WORKED EXAMPLE

Boilerhouse: MAIN

Year: 1988/89

Measure No.	Measure Description	Assumptions	Baseload savings (GJ/annum) A	Heat load savings (GJ/annum) B	Total savings (GJ/annum) C
1	PROMOTE AWARENESS	APPROX. 1% ACTUAL			
	OF ENERGY SAVINGS	CONSUMPTION	120	120	240
2	DRAUGHT PROOF	ACR 1.5 → 1.0		58	58
3	DRAUGHT PROOF SOME OTHERS	VARIOUS ACR REDUCTIONS		421	421
4	REDUCE SPARE TEMP	VARIOUS REDUCTIONS		141	141
5	ALTER CONTROLS B2	5% ACTUAL		50	50
6	- - - - - B3	CONSUMPTION		216	216
7	- - - - - B9	— · —		76	76
	Sub Total		120	1082	1202
	Resulting circulation/distribution saving = Total savings above × percentage loss		144		144
	Total		264	1082	1346

	GJ/Annum	
Revised baseload	11136	Form 3 less A
Revised heat load	13828	Form 3 less B
Revised total consumption	24964	Form 3 less C

Standard Stationery

ESAM Part 3 Capital expenditure boilerhouse energy savings	FORM 16 Date: MAY 1989

Health Authority: ..... Hospital: WORKED EXAMPLE

Boilerhouse: MAIN Year: 1988/89

Assessed annual efficiency: 75 %

Potential annual efficiency: 77 %

Baseload savings (GJ/annum) A	Heat load savings (GJ/annum) B	Total savings (GJ/annum) C
289	359	648

(see Note 1)

Measures adopted

Notes:

(1) Savings = $\frac{\text{Previous load}^{(2)} \times \%\text{ improvement in efficiency}}{\text{Potential annual efficiency}}$ (Transfer these savings to Form 18)

(2) Previous load from Form 3, or where Good Housekeeping measures have been implemented, Form 15

Standard Stationery

ESAM Part 3
Capital expenditure building energy savings

FORM 17
Date: MAY 1989

Health Authority: ..... Hospital: WORKED EXAMPLE
Boilerhouse: MAIN Year: 1988/89
Building Title/Function: A&E AND OPD Building Ref: 5

BUILDINGS		Heat loss factor[1]	Area/ volume[2]	Intermittent heating factor	New heat loss (GJ/annum)	Original heat loss (GJ/annum)	Heat saving (GJ/annum)	Boiler house efficiency[3]	Energy saving (GJ/annum)	
Element	Structural change	A	B	C	D = A×B×C	E	F = E − D	G	H = F/G	
Wall										
Roof										
Floor										
Ventilation										
								Building Total		

CONTROLS			% improvement	Heat loss[4] (GJ/annum)	Heat saving (GJ/annum)	B/h efficiency[3] %	Energy saving (GJ/annum)	
Control Type	Description		A	B	C = A×B / 100	D	E = C / D	
ZONE AND TIME	OPD SECTION REDUCED TO 5DAY/WEEK + 12 HOURS/DAY		7	1271	89	77	116	
NB						Controls Total		116
FROM FORM 11 NOT SHOWN						GRAND TOTAL		116

	GJ/annum	
Heat load savings[5]	106	Transfer these savings to Form 18
Baseload savings[6]	13	
Total savings	119	

Notes:

(1) GJ/annum m^2 (walls, roofs, floors)
GJ/annum m^3 (ventilation)

(2) m^2 (areas)
m^3 (volumes)

(3) Either the potential value shown on FORM 16, or the actual assessed value if no improvements are envisaged.

(4) Either the new heat loss from the building section above, or that shown on FORM 11 if no fabric improvements have been included.

(5) Heat load saving = Degree Day corrected energy saving = $\frac{\text{Energy saving} \times \text{Boilerhouse Heating Season DDs}}{\text{National Average DDs}}$

(6) Baseload savings resulting = heat load saving × % distribution/circulation loss

Standard Stationery

ESAM Part 3
Capital expenditure building energy savings

FORM 17
Date: MAY 1989

Health Authority: .....
Hospital: WORKED EXAMPLE
Boilerhouse: MAIN
Year: 1988/89
Building Title/Function: ADULT ACUTE WARD
Building Ref: 2

BUILDINGS		Heat loss factor[1]	Area/ volume[2]	Intermittent heating factor	New heat loss (GJ/annum)	Original heat loss (GJ/annum)	Heat saving (GJ/annum)	Boiler house efficiency[3]	Energy saving (GJ/annum)	
Element	Structural change	A	B	C	D = A×B×C	E	F = E − D	G	H = F/G	
Wall	INSULATE WALLS	0·82	472	1	387	425	38	0·77	49	
Roof	APPLY EXTERNAL INSULATION	0·14	674	1	94	155	61	0·77	79	
Floor										
Ventilation										
								Building Total		128

CONTROLS		% improvement	Heat loss[4] (GJ/annum)	Heat saving (GJ/annum)	B/h efficiency[3] %	Energy saving (GJ/annum)	
Control Type	Description	A	B	$C = \frac{A \times B}{100}$	D	$E = \frac{C}{D}$	
						Controls Total	
						GRAND TOTAL	128

	GJ/annum	
Heat load savings[5]	124	Transfer these savings to Form 18
Baseload savings[6]	15	
Total savings	139	

Notes:

(1) GJ/annum m^2 (walls, roofs, floors)
GJ/annum m^3 (ventilation)

(2) m^2 (areas)
m^3 (volumes)

(3) Either the potential value shown on FORM 16, or the actual assessed value if no improvements are envisaged.

(4) Either the new heat loss from the building section above, or that shown on FORM 11 if no fabric improvements have been included.

(5) Heat load saving = Degree Day corrected energy saving = $\frac{\text{Energy saving} \times \text{Boilerhouse Heating Season DDs}}{\text{National Average DDs}}$

(6) Baseload savings resulting = heat load saving × % distribution/circulation loss

Standard Stationery

ESAM Part 3
Summary of capital investment energy savings

FORM 18
Date: MAY 1989

Health Authority: .....
Hospital: WORKED EXAMPLE
Boilerhouse: MAIN
Year: 1988/89

Measure No.	Measure Description	Baseload savings (GJ/annum) A	Heat load savings (GJ/annum) B	Total savings (GJ/annum) C
1	BOILER HOUSE IMPROVEMENT			
	(FORM 16)	289	359	648
2	BUILDING IMPROVEMENT B2			
	(FORM 17)	15	124	139
	BUILDING IMPROVEMENTS TO:			
3	B1 (FORM 17 NOT SHOWN)	59	495	554
4	B3 — .. — — .. —	128	1069	1197
5	B6 — . - — . —	17	142	159
6	B9 — .. — — .. —	38	318	356
7	CONTROL IMPROVEMENT			
	B5 (FORM 17)	13	106	119
	Total:	559	2613	3172

	GJ/annum	
Revised baseload	10841	Form 3 less A
Revised heat load	12297	Form 3 less B
Revised total consumption	23138	Form 3 less C

ENCODE

Standard Stationery

ESAM Part 3 Cost evaluation of all Energy Saving Measures			FORM 19 Date: MAY 1989
Health Authority: ..... Hospital: WORKED EXAMPLE All Boiler Houses: ..... Year: 1988/89			
Energy saving measure	Fuel consumption saving (GJ/annum)	Cost per GJ supplied (£)	Cost saving (£/annum)
GOOD HOUSEKEEPING MEASURES			
(FORM 15)	1346	3.75	5048
BOILER HOUSE IMPROVEMENTS			
(FORM 16)	648	3.75	2430
BUILDING IMPROVEMENT B2			
(FORM 17)	139	3.75	521
BUILDING IMPROVEMENTS TO:			
B1 (FORM 17 NOT SHOWN)	554	3.75	2077
B3 (— ·· — — · —)	1197	3.75	4489
B6 (— ·· — — · —)	159	3.75	596
B9 (— ·· — — ·· —)	356	3.75	1335
CONTROL IMPROVEMENTS			
B5 (FORM 17)	119	3.75	446
Totals	4518		16942

	GJ/annum
Revised baseload	10577
Revised heat load	11215
Revised total consumption	21792

Transferred from Forms 15 and 18 as appropriate to measures implemented.

ENCODE Miscellaneous calculations	**FORM 20** Date: MAY 1985

Standard Stationery

ENCODE Option sheet for energy efficient measures	**FORM 21** Date: MAY 1985

1 Site name/code _____

_____

2 Location on site _____

_____

3 Nature of measure _____

_____

_____

4 Effect on site conditions
Temperature _____

Air change _____

Air conditioning _____

Lighting _____

5 Resources needed
Design time _____

Design cost £ _____

Labour time _____

Labour cost £ _____

Materials _____

_____

Materials cost £ _____

Equipment _____

_____

Equipment charges £ _____

6 Capital cost £ _____

7 Annual running cost £ _____

8 Annual maintenance cost £ _____

9 Expected life of option _____

_____

10 Inter action with other energy saving measures:
a) Projected in the same area _____

_____

b) Invalidated by this option _____

_____

11 Timing of other energy saving measures to be carried out relative to this option:
a) Before _____

_____

b) During _____

_____

c) After _____

_____

12 Priority _____

13 Urgency _____

14 Time required to implement _____

_____

15 Time of year restrictions _____

16 Associated upgrading schemes _____

_____

_____

17 Disruptions to staff and/or patients _____

_____

How can they be minimised _____

_____

18 Approvals: _____

_____

_____

_____

_____

_____

_____

_____

18 Proceed
As above _____

With modifications _____

_____

_____

ESAM Part 1 Site details	**FORM 1** Date:

Health Authority: ..... Hospital: .....

Year: .....

Site Degree Day area

Site exposure[1]

Boilerhouses

Name	Degree Day Base (Hospital/Standard)	Annual Degree Days[2]	Heating Season Degree Days[3]

Comments: (e.g., boiler sequencing, seasonal shutdown, etc.)

Notes:

(1) Sheltered, Normal or Severe. See CIBSE GUIDE A3.

(2) The 20 year site average for the Degree Day Base specified.

(3) As above, less the Degree Days for those months when the heating is turned off.

Standard Stationery

ESAM Part 1 Record of monthly fuel consumption and Degree Days	**FORM 2** Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

	Fuel	Units	Factor to Convert to GJ
1.	.....	.....	.....
2.	.....	.....	.....
3.	.....	.....	.....

Month	Fuel consumption (units of supply) Fuel 1	Fuel 2	Fuel 3	Total consumption (GJ)	Degree Days (Hospital/ Standard)[1]
APR					
MAY					
JUN					
JUL					
AUG					
SEP					
OCT					
NOV					
DEC					
JAN					
FEB					
MAR					
TOTAL					

Notes:
[1] Delete as applicable

Standard Stationery

ESAM Part 1 Analysis of actual performance	FORM 3 Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

	Month	Consumption[1] (GJ) y	Degree[1] Days x	$xy \div 10^6$	$y^2 \div 10^6$	$x^2 \div 10^6$
1	APR					
2	MAY					
3	JUN					
4	JUL					
5	AUG					
6	SEP					
7	OCT					
8	NOV					
9	DEC					
10	JAN					
11	FEB					
12	MAR					
TOTAL						
Exclusions:						
NEW TOTAL						

(2)

$K = \Sigma(x^2)\,10^6 - \frac{(\Sigma x)^2}{n}$ = ____ $L = \Sigma(y^2)\,10^6 - \frac{(\Sigma y)^2}{n}$ = ____

$M = \Sigma(xy)\,10^6 - \frac{\Sigma x \Sigma y}{n}$ = ____ Correlation = $\frac{M}{\sqrt{K \times L}}$ = ____

Actual space heating factor = $\frac{M}{K}$ = ____ GJ/DD

Actual monthly base load = $\frac{\Sigma y - \frac{M \Sigma x}{K}}{n}$ = ____ GJ/month

Average Degree Days/month = ____ DD/month

Average consumption/month = ____ GJ/month

Annual base load = monthly base load × 12 = ____ GJ/annum

Annual space heating load = Total consumption − annual baseload

= ____ GJ/annum

Notes: (1) Taken from Form 2 (2) n = number of months

ENCODE

Standard Stationery

ESAM Part 1 Assessed baseload	FORM 4 Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Boilerhouse efficiency		%
Cold water consumption		m^3/month
Hot water consumption		m^3/month
Temperature difference		°C
Ancillary steam consumption		kg/month
Distribution/circulation loss		%

	Energy requirement (GJ/month)	Boilerhouse[4] load (GJ/month)
DHWS[1]		
Ancillary Steam[2]		
Distribution/ circulation[3]		
TOTAL		

Notes

(1) Energy requirement for DHWS

$$= \frac{\text{Hot water consumption} \times \text{temperature difference} \times 1000 \times 4.2}{10^6}$$

(2) Energy requirement for ancillary steam

$$= \frac{\text{Consumption in kg/month} \times 2304}{10^6}$$

(3) Energy loss to distribution and circulation

= Distribution/circulation loss × average monthly consumption

(4) Boilerhouse load $= \frac{\text{Energy requirement}}{\text{efficiency}}$

Standard Stationery

ESAM Part 1 Ancillary steam usage	FORM 5 Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Equipment	No.	kg/hr	Hrs/day	Days/ month	Cycle diversity	kg/month

Standard Stationery

ESAM Part 1 Assessed heat load	FORM 6 Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Bldg. Ref.	Title/Function	Type of construction[1]	Heated volume[2] (m^3) A	Heatloss/unit volume[3] (W/m^3) B	Assessed heatloss (kW) A × B/1000
		TOTALS			

Assessed space heating factor [4] _____ GJ/DD

Notes

(1) Identify basic form of construction, eg, Traditional brick/pitched tile roof, System built/flat roof, Prefab asbestos/pitched roof, etc.

(2) Exclude all unheated spaces.

(3) Refer to Table 9 for typical values.

(4) Assessed space heating factor

$$= \frac{\text{Total heat loss} \times 3600 \times 24}{(\text{DD base temp} - \text{design temp}) \times 10^6 \times \text{efficiency}}$$

where DD base temp is 18.5°C for Hospital DDs or 15.5°C for Standard DDs, and design temp = −1°C.

Standard Stationery

ESAM Part 2 Boiler details			FORM 7 Date:
Health Authority:		Hospital:	
Boilerhouse:		Year:	
Boilers			
Type			
Rating			
Age			
Condition			
Feed pumps			
Fuel storage and handling			
Log sheet records			
Blowdown			
Water treatment			
Instrumentation and metering			
Flue temperature			
CO_2			
Smoke number			
Water treatment			
Hours run			
Oxygen			

Standard Stationery

ESAM Part 2 Reassessed baseload	FORM 8 Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

The entries on this form should be obtained by a more rigorous procedure than those on Form 4 (ESAM Part 1).

Boiler house efficiency		%
Cold water consumption		m^3/month
Hot water consumption		m^3/month
Temperature difference		°C
Ancillary steam consumption		kg/month
Distribution/circulation loss		%

	Energy requirement (GJ/month)	Boilerhouse[4] load (GJ/month)
DHWS[1]		
Ancillary Steam[2]		
Distribution/ circulation[3]		
TOTAL		

Notes

(1) Energy requirement for DHWS

$$= \frac{\text{Hot water consumption} \times \text{temperature difference} \times 1000 \times 4.2}{10^6}$$

(2) Energy requirement for ancillary steam

$$= \frac{\text{Consumption in kg/month} \times 2304}{10^6}$$

(3) Energy loss to distribution and circulation

= Distribution/circulation loss × average monthly consumption

(4) Boilerhouse load $= \frac{\text{Energy requirement}}{\text{efficiency}}$

Standard Stationery

ESAM Part 2 Building details			FORM 9 Date:
Health Authority:		Hospital:	
Boilerhouse:		Year:	
Building Title/Function:		Building Ref:	
Construction[1]		Type of occupancy[4]	
Number of floors		Number of days/week	
Floor to ceiling height (m)		Time from	
Heated volume (m^3)[2]		Time to	
External wall area (m^2)		Number of hours/day	
Floor area (m^2)			
Roof area (m^2)			
Air change rate (/hr)			
Plant response rate[3]			

Walls Type		Notes
Materials/thickness		
Cavity size		
Insulation		
U value		
Glazing % single		
U value single		
% double		
U value double		
Roof Type	Flat/Pitched	
Materials/thickness		
U value		
Floor Type	Solid/Ventilated	
Materials/thickness		
U value		

Notes

(1) Heavy, Medium or Light.

(2) See Chapter 7 for definitions of measured volumes and areas.

(3) Fast, Medium or Slow.

(4) E.g., Ward, Dining, Admin.

Standard Stationery

ESAM Part 2 Heating system and controls (details)	**FORM 10A** Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Building Title/Function: ..... Building Ref: .....

Form of heating[1]:

Circulation mains[2]:

Insulation:

Heating plant[3]:

Age:

Heating controls: Buildings[3]

Age:

Heating controls: Plant[3]

Age:

Notes

(1) Identify type(s) of heating service and form of circulation, e.g., single or two pipe.

(2) Do circulation mains separately serve buildings with mixed occupancy and departments or areas with intermittent occupation.

(3) Identify type and age (if necessary age range) of heating plant and heating controls on the building and plant.

Standard Stationery

ESAM Part 2 Heating system and controls (sketch)	**FORM 10B** Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Building Title/Function: ..... Building Ref: .....

Draw a single line sketch of heating system layout, indicating position and type of existing controls, time switches and sensors.

Indicate control manufacturers.

ENCODE

Standard Stationery

ESAM Part 2 Building heat loss assessment	FORM 11 Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Building Title/Function: ..... Building Ref: .....

Element	Heat loss factor[1] A	Area/ volume[2] B	Intermittent heating factor[3] C	Heat loss (GJ/annum) D = A × B × C	Notes
Wall					
Roof					
Floor					
Ventilation					
			Total		GJ/annum
		Degree Day corrected heat loss[4]			GJ/annum

Notes

(1) GJ/annum m^2 (walls, roofs, floors)
GJ/annum m^3 (ventilation)

(2) m^2 (areas)
m^3 (volumes)

(3) From Table 14

(4) Degree Day corrected heat loss

$$= \frac{\text{Heat loss} \times \text{Boilerhouse Heating Season DDs}}{\text{National average annual DDs}}$$

where the National average = 3448 (for Hospital DDs) or
2462 (for Standard DDs)

ESAM Part 2 Summary of assessed heat loss	**FORM 12** Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Building Ref.	Title/Function	DD[1] corrected heat loss (GJ/annum)	Building Ref.	Title/Function	DD[1] corrected heat loss (GJ/annum)
	Sub total			Total	

Notes

(1) From Form 11

Standard Stationery

ESAM Part 2 Energy Audit Balance Sheet	**FORM 13** Date:

Health Authority: ..... Hospital: .....

Year: .....

Energy source	B/h eff.	Assessed monthly baseload (GJ/month)	Assessed annual baseload[1] (GJ/annum)	DD corrected heat loss (GJ/annum)	Assessed annual heat load[2] (GJ/annum)	Assessed space heating factor[3] (GJ/DD)	Total assessed annual load[4] (GJ/annum)	Actual energy consumption[5] (GJ/annum)
TOTALS								
						Potential saving = actual − assessed		
						% saving		

Notes

(1) Monthly baseload × 12

(2) $\frac{\text{DD corrected heat loss}}{\text{boilerhouse efficiency}}$

(3) $\frac{\text{Assessed annual heat load}}{\text{Boilerhouse annual DDs (from Form 1)}}$

(4) Assessed annual baseload + assessed heat load

(5) From Form 2

Standard Stationery

ESAM Part 3 Draught Proofing	FORM 14 Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Select the heat loss factor for the new air change rate from Table 13 and calculate the saving as shown and enter on Form 15.

Building Ref.	Heat loss factor (GJ/annum/m^3) A	Volume (m^3) B	Intermittent heating factor C	New heat loss (GJ/annum) D = A × B × C	Original heat loss (GJ/annum) E	Heat saving (GJ/annum) F = E − D	Boiler house efficiency % G	Energy saving (GJ/annum) H = F/G	DD(1) corrected energy saving (GJ/annum) J

GJ/annum

Total Saving

(1) Degree Day corrected energy saving

$$= \frac{\text{Energy saving} \times \text{Boilerhouse Heating Season DDs}}{\text{National average annual DDs}}$$

Standard Stationery

ESAM Part 3 Summary of Good Housekeeping energy savings	FORM 15 Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Measure		Assumptions	Baseload savings (GJ/annum) A	Heat load savings (GJ/annum) B	Total savings (GJ/annum) C
No.	Description				
Sub Total					
Resulting circulation/distribution saving = Total savings above × percentage loss					
Total					

	GJ/Annum	
Revised baseload		Form 3 less A
Revised heat load		Form 3 less B
Revised total consumption		Form 3 less C

Standard Stationery

ESAM Part 3 Capital expenditure boilerhouse energy savings	**FORM 16** Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Assessed annual efficiency [ ] %

Potential annual efficiency [ ] %

Baseload savings (GJ/annum) A	Heat load savings (GJ/annum) B	Total savings (GJ/annum) C

(see Note 1)

Measures adopted

Notes:

(1) Savings = $\frac{\text{Previous load}^{(2)} \times \%\text{ improvement in efficiency}}{\text{Potential annual efficiency}}$ (Transfer these savings to Form 18)

(2) Previous load from Form 3, or where Good Housekeeping measures have been implemented, Form 15

ENCODE

Standard Stationery

ESAM Part 3

Capital expenditure building energy savings

FORM 17

Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Building Title/Function: ..... Building Ref: .....

BUILDINGS										
Element	Structural change	Heat loss factor[1] A	Area/ volume[2] B	Intermittent heating factor C	New heat loss (GJ/annum) D = AxBxC	Original heat loss (GJ/annum) E	Heat saving (GJ/annum) F = E – D	Boiler house efficiency[3] G	Energy saving (GJ/annum) H = F/G	
Wall										
Roof										
Floor										
Ventilation										
								Building Total		

CONTROLS							
Control Type	Description	% improvement A	Heat loss[4] (GJ/annum) B	Heat saving (GJ/annum) C = A x B / 100	B/h efficiency[3] % D	Energy saving (GJ/annum) E = C / D	
						Controls Total	
						GRAND TOTAL	

	GJ/annum	
Heat load savings[5]		Transfer these savings to Form 18
Baseload savings[6]		
Total savings		

Notes:

(1) GJ/annum m^2 (walls, roofs, floors)
GJ/annum m^3 (ventilation)

(2) m^2 (areas)
m^3 (volumes)

(3) Either the potential value shown on FORM 16, or the actual assessed value if no improvements are envisaged.

(4) Either the new heat loss from the building section above, or that shown on FORM 11 if no fabric improvements have been included.

(5) Heat load saving = Degree Day corrected energy saving = $\frac{\text{Energy saving} \times \text{Boilerhouse Heating Season DDs}}{\text{National Average DDs}}$

(6) Baseload savings resulting = heat load saving x % distribution/circulation loss

Standard Stationery

ESAM Part 3 Summary of capital investment energy savings	**FORM 18** Date:

Health Authority: ..... Hospital: .....

Boilerhouse: ..... Year: .....

Measure		Baseload savings (GJ/annum) A	Heat load savings (GJ/annum) B	Total savings (GJ/annum) C
No.	Description			
	Total:			

GJ/annum

Revised baseload		Form 3 less A
Revised heat load		Form 3 less B
Revised total consumption		Form 3 less C

ENCODE

Standard Stationery

ESAM Part 3 Cost evaluation of all Energy Saving Measures			**FORM 19** Date:
Health Authority: ..... Hospital: ..... All Boiler Houses: ..... Year:			
Energy saving measure	Fuel consumption saving (GJ/annum)	Cost per GJ supplied (£)	Cost saving (£/annum)
Totals			

	GJ/annum
Revised baseload	
Revised heat load	
Revised total consumption	

Transferred from Forms 15 and 18 as appropriate to measures implemented.

Standard Stationery

ENCODE Miscellaneous calculations	**FORM 20** Date:

Standard Stationery

ENCODE Option sheet for energy efficient measures	**FORM 21** Date:

1 Site name/code _____

_____

2 Location on site _____

_____

3 Nature of measure _____

_____

_____

4 Effect on site conditions
Temperature _____

Air change _____

Air conditioning _____

Lighting _____

5 Resources needed
Design time _____

Design cost £ _____

Labour time _____

Labour cost £ _____

Materials _____

_____

Materials cost £ _____

Equipment _____

_____

Equipment charges £ _____

6 Capital cost £ _____

7 Annual running cost £ _____

8 Annual maintenance cost £ _____

9 Expected life of option _____

_____

10 Inter action with other energy saving measures:
a) Projected in the same area _____

_____

b) Invalidated by this option _____

_____

11 Timing of other energy saving measures to be carried out relative to this option:
a) Before _____

_____

b) During _____

_____

c) After _____

_____

12 Priority _____

13 Urgency _____

14 Time required to implement _____

_____

15 Time of year restrictions _____

16 Associated upgrading schemes _____

_____

_____

17 Disruptions to staff and/or patients _____

_____

How can they be minimised _____

_____

18 Approvals: _____

_____

_____

_____

_____

_____

_____

_____

18 Proceed
As above _____

With modifications _____

_____

_____

Assessment of Electricity Consumption

ESAM ELECTRICAL Record of monthly electricity consumption and Maximum Demand	**FORM E1**

Health Authority ..... Hospital .....

.....

HOSPITAL : ..... **BLOCK :** .....

YEAR : .....

	Elec. Consumed	**Maximum Demand**
APRIL	.....	.....
MAY	.....	.....
JUNE	.....	.....
JULY	.....	.....
AUG	.....	.....
SEPT	.....	.....
OCT	.....	.....
NOV	.....	.....
DEC	.....	.....
JAN	.....	.....
FEB	.....	.....
MAR	.....	.....
TOTAL	.....	.....

ENCODE

ESAM ELECTRICAL Schedule of Luminaires	**FORM E2**

Health Authority: ..... Hospital: .....

Type: ..... No. Beds: ....

DIVERSITY FACTOR FOR ASSESSING LIGHTING LOADS

DARK ROOM, LOW REFLECTANCES, SMALL WINDOWS, PREDOMINANTLY NORTH FACING, LEVEL > 300 LUX REQUIRED. $f = 1.0$

LIGHT ROOM, HIGH REFLECTANCES, LARGE WINDOWS, PREDOMINANTLY SOUTH FACING, LEVEL > 300 LUX REQUIRED. $f = 0.5$

Bldg. Group Ref.	Title and Function	Type of Load	Max — Circuit Load	f	Occ. Hrs.	Total Load (kWhrs)
		- LIGHTING -				
Totals				**TOTAL:**		

ESAM ELECTRICAL Schedule of Power Requirement						**FORM E3**
Health Authority ..... Hospital						
Bldg. Group Ref.	Title and Function	Type of Load	Max — Circuit Load	Div. Factor	Occ. Hrs.	Total Load (kWhrs)
Totals						

TYPE OF LOAD: **POWER – FIXED EQUIPMENT**
POWER – PORTABLE EQUIPMENT
CATERING EQUIPMENT
LIFTS
OTHER

NOTES: LIGHTING, USE FORM E2.
TOTAL EACH LOAD TYPE AND ENTER ONTO FORM E4

Assessment of Electricity Consumption

ESAM ELECTRICAL Electrical Audit Balance Sheet	**FORM E4**

Health Authority ..... Hospital .....

.....

	LOAD TYPE		TOTAL ASSESSED LOAD FROM FORMS E1 & E2		
1.	LIGHTING				
2.	POWER – PORTABLE EQUIPMENT				
3.	POWER – FIXED EQUIPMENT				
4.	CATERING EQUIPMENT				
5.	LIFTS				
6.	OTHER				

TOTAL ASSESSED LOAD:	kWhrs
TOTAL SITE LOAD: (FROM BILLS)	kWhrs
POTENTIAL SAVING:	kWhrs

ESAM ELECTRICAL Energy Saving Proposals					**FORM E5**
Health Authority ..... Hospital					
Building ref.	Description of proposal	Capital cost £	Saving kW hrs	Saving £	Pay-back Years

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NHS Estates is an Executive Agency of the Department of Health and is involved with all aspects of health estate management, development and maintenance. The Agency has a dynamic fund of knowledge which it has acquired during 30 years of working in the field. Using this knowledge NHS Estates has developed products which are unique in range and depth. These are described below.

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Encode is a key guidance document which describes how to improve energy efficiency in existing health care establishments by means of a comprehensive strategy to facilitate progress from piecemeal to total energy management; it complements the information available from the Energy Efficiency Office.

Encode is published as a set of three documents; this volume – Encode 1 – contains information on the Energy Survey and Audit Method (ESAM), energy monitoring, identifying potential energy-saving measures and energy management planning.

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